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L.E. CARPENTER AND COMPANY
FINAL FEASIBILITY STUDY REPORT

October 1993

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EXECUTIVE SUMMARY

L.E. Carpenter and Company (L.E. Carpenter) is pleased to submit this Final Feasibility Study (FS) for the former manufacturing facility located in Wharton, New Jersey. In accordance with the NJDEPE Amended Administrative Consent Order (ACO), Roy F. Weston, Inc. (WESTON®) has prepared this FS to develop and evaluate remedial alternatives for the site which are capable of mitigating unacceptable chemical and environmental risks as determined by the Baseline Risk Assessment (RA).

This Feasibility Study is based upon findings of Remedial Investigations (RI) conducted at the site in 1989, 1990, and 1991, as well as post-RI field activities conducted in 1993. The Draft Feasibility Study was submitted in May 1991. NJDEPE and EPA provided comments to L.E. Carpenter in June and July 1991. This final FS has incorporated and addressed those comments.

The L.E. Carpenter facility is located at 170 North Main Street, Borough of Wharton, Morris County, New Jersey. The facility was designed and operated as a manufacturing facility for vinyl wall coverings from 1943 to 1987. The sites occupies approximately 14.6 acres northwest of the intersection of the Rockaway River and North Main Street. The site is situated within a mixed commercial/industrial/residential area. The Rockaway River borders the site to the south; a vacant lot lies to the east; and a large compressed gas facility (Air Products, Inc.) border the site to the northeast. Additional industrial sites are located to the south of the site.

The RI concluded that contaminants have been or may have been released from a variety of sources at the site. The identified sources include:

- An unlined surface impoundment
- Process discharges
- Raw material storage
- The former tank farm area and other USTs
- On-site disposal
- Historical coal storage and mining operations

Except for the disposal area in the northeastern corner of the site, these sources have since been removed or have ceased operation. However, secondary sources remain. These include the immiscible product layer, contaminated soil, the former disposal area, and contaminated groundwater.

In general, contaminants have historically moved into the soil and eventually leached (depending on their solubility) to the shallow groundwater. The former tank farm, underground storage tanks, and unlined lagoon have all been removed and disposed of off site. A dissolved organic contaminant plume is present in shallow groundwater, above the clay layer, on site and in the immediate vicinity of the L.E. Carpenter site. The plume is comprised mainly of xylene, ethylbenzene, toluene, and DEHP. The shallow groundwater plume appears to be contained by the Air Products drainage ditch and a variable clay lens on the Wharton Enterprises property.

The plume extends approximately 200 feet onto the Wharton Enterprises property. The areal limit of the plume has been established.

Historical migration and seasonal fluctuation of the floating product and contaminated groundwater has contacted and, in turn, contaminated soils near the water table. Isolated areas, mainly associated with building loading docks and raw material storage, contain elevated levels of lead in surface soils.

Contaminant migration has been mitigated and slowed by the implementation of a passive product recovery system which has been operational since 1984. The system, which was upgraded in 1991, currently recovers approximately 400 gallons a quarter.

L.E. Carpenter conducted an ecological assessment of Rockaway River sediments in September 1992. In that assessment, the structure of the benthic macroinvertebrate community of the Rockaway River was quantified in terms of taxonomic diversity, numerical abundance and function and evaluated in light of biotic and abiotic environmental variables. Evidence of adverse ecological effects resulting from contaminants detected in the sediment were not observed in the Rockaway River adjacent to the L.E. Carpenter site or in any portion of the Rockaway River studied. The historical operations on site and current conditions of the site are not impacting the biological community in the sediment or water environments of the Rockaway River. The Ecological Assessment report concluded that remediation efforts specific to Rockaway River sediments or surface water are not warranted. In a letter from NJDEPE Bureau of Federal Case Management to L.E. Carpenter and Company dated 3 February 1993, NJDEPE and U.S. EPA agreed with this conclusion.

The L.E. Carpenter Baseline Risk Assessment, which was performed in accordance with the Risk Assessment Guidance for Superfund (RAGS), was used as a starting point to identify the contaminants that require remediation. Subsequently, the concentrations of these contaminants were compared to NJDEPE Cleanup Standards, which are available for soil and groundwater. The draft NJDEPE Cleanup Standards specify criteria to determine compliance with soil standards. These criteria include such items as: (1) the arithmetic mean of a constituent in samples collected from an area of concern; (2) no more than ten percent of the samples exceed the cleanup standard for each chemical constituent; and (3) no single soil sample exceeds its applicable soil standard by a factor of ten (for standards less than or equal to 10 ppm), five (for standards between 10 and 100 ppm), or two (for soil standards greater than 100 ppm). Also taken into consideration were the frequency of detection and the likelihood that the contaminant is site-related and not from blank contamination or upgradient/regional sources. Based on this evaluation, the chemicals that require remediation for each media are identified in Table ES-1.

TABLE ES-1

MEDIA SPECIFIC CONTAMINANTS OF CONCERN
FOR THE L.E. CARPENTER SITE

MEDIA	CONTAMINANT
Soil, Groundwater	DEHP
Soil, Groundwater	Xylenes
Soil, Groundwater	Ethylbenzene
Soil, Groundwater	Antimony
Soil - Hotspots	Lead
Soil - Hotspots	PCBs
Groundwater	Arsenic

In the comparative analysis of alternatives, each option is evaluated in relation to one another based on the following evaluation criteria:

- Overall protection of human health and the environment,
- Compliance with ARARs,
- Long-term effectiveness and permanence,
- Reduction of toxicity, mobility, and volume of contaminants through treatment,
- Short-term effectiveness, and
- Implementability and costs.

The purpose of this analysis is to identify the relative advantages and disadvantages of each alternative. The remedial alternatives evaluated in the FS, and fully discussed in Chapter 6, are:

- Alternative 1: No Action
- Alternative 2: Institutional Controls
- Alternative 3: Groundwater Treatment
- Alternative 4: Groundwater Treatment with Reinfiltration
- Alternative 5: Excavation/On-Site Soil Washing/Bioslurry Treatment
- Alternative 6: Excavation/Thermal Treatment

A summary of each remedial alternative with respect to the evaluation criteria is presented in Table 6-11. Alternatives 3 and 4 meet or exceed each of the non-cost evaluation criteria, although Alternative 3 does not meet the proposed New Jersey soil cleanup standards, which are TBCs. All other alternatives considered were found not to meet and/or have major limitations with at least two of the non-cost evaluation criteria. Alternative 3 (Groundwater Treatment) utilizes a phased approach to remediating groundwater. During Phase I floating product is actively removed through pumping product and groundwater, physically separating the two phases, disposing the product and recharging the groundwater to the shallow aquifer. Phase II incorporates active pumping of groundwater for aquifer restoration. The groundwater will be treated in an aboveground biological reactor. A major portion of the treated water will be recirculated in the treatment zone. The remainder of this water will be polished through activated carbon beds and discharged to groundwater. Alternative 3 also includes installation of a soil cap over much of the site to reduce surface erosion, and removal and off-site disposal of limited amounts of "hot spot" soils which contain metals and PCBs at concentrations above actionable levels.

Alternative 4 (Groundwater Treatment with Reinfiltration) also utilizes a phased approach to remediating groundwater. As in Alternative 3, during Phase I floating product is actively removed by pumping product and groundwater, physically separating the two phases, disposing the product and recharging the groundwater to the shallow aquifer. Phase II incorporates active pumping and treatment in an aboveground biological reactor of groundwater for groundwater restoration. In Alternative 4 a major portion of the water will be recirculated to the treatment zone where soils are product contaminated. This infiltrated water will be amended with oxygen, nutrients and possibly a surfactant in order to effect flushing and biological degradation of product adhering to soil particles.

The remainder of the treated water will be polished through activated carbon beds and discharged to groundwater. Installation of a soil cap is provided for in Alternative 4 to reduce surface erosion and protect the groundwater infiltration system. Alternative 4 also includes removal and disposal of potential source areas such as limited "hot spot" soils and the former on-site disposal area in the northeastern corner of the site.

Alternative 4 exceeds the performance of Alternative 3 in compliance with ARARs, in long-term effectiveness and permanence, and in reduction in toxicity, mobility, and volume of contaminants; the two alternatives were judged to be roughly equal in the other evaluation criteria. Alternative 3 (Groundwater Treatment) at an estimated cost of $8.94 million or Alternative 4 (Groundwater Treatment with Reinfiltration) at an estimated cost of $11.0 million, are the recommended alternatives.

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MANAGERS DESIGNERS/CONSULTANTS

SECTION 1.0

INTRODUCTION

The Feasibility Study (FS) is the mechanism for the development, screening, and detailed evaluation of alternatives for remedial actions. The primary objective of the FS for the L.E. Carpenter site is to develop and evaluate remedial action alternatives for the site which are capable of mitigating unacceptable chemical and environmental risks as determined in the Baseline Risk Assessment (RA). The approach and structure of the FS are in accordance with the U.S. Environmental Protection Agency's (EPA) Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA (1988). The FS is based on the characterization of the site from the Remedial Investigation (RI) and the Supplemental Remedial Investigations, and the potential impact of the site on human health and the environment as determined in the Baseline Risk Assessment (RA).

This FS addresses environmental media only. The approach for decommissioning the building interiors has been addressed separately. Underground storage tanks on site have been removed under an approved closure plan submitted to the NJDEPE in January 1991. The floating product is currently being recovered at an approximate rate of 400 gallons per month using a series of recovery wells placed in various locations on the property.

The objectives of the remedial action at the L.E. Carpenter site are to:

- Remediate the possible environmental and human health impacts by reducing contaminant levels, exposure, or both in compliance with the requirements of the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA, also known as Superfund), the Superfund Amendments and Reauthorization Act of 1986 (SARA), and state-established regulations for the site.

- Enable delisting of the site from the National Priorities List (NPL) after completion of remediation.

1.1 SITE DESCRIPTION

A detailed description of the site is provided in the RI and Supplemental RI reports (1990, 1992). A summary of that information is provided in this report.

The L.E. Carpenter facility is located at 170 North Main Street, Borough of Wharton, Morris County, New Jersey. The location of the facility is shown in Figure 1-1, Topographic Map of the L.E. Carpenter Facility, Wharton, New Jersey. The facility comprises Block 301, Lot 1 and Block 703, Lot 30 on the tax map of the Borough of Wharton.

The L.E. Carpenter facility was designed and operated as a manufacturing facility for vinyl wall coverings from 1943 to 1987. It is currently utilized as subleased warehouse space and for manufacturing.

Figure 1-2 depicts the major features of the site and illustrates the immediate environmental setting. The site occupies approximately 14.6 acres northwest of the intersection of the Rockaway River and North Main Street. The site is situated within a mixed commercial/ industrial/residential area. The Rockaway River borders the site to the south; a vacant lot (Wharton Enterprises, Inc.) lies to the east; and a large compressed gas facility (Air Products Inc.) borders the site to the northeast. Additional industrial sites are located to the south of the site. The residential portion of the Borough of Wharton is separated from the site by Ross Street, which is located on the northwestern side of the site.

1.1.1 Geology

As shown by the on-site well logs and literature studies, the geology of the L.E. Carpenter site is generally characterized by layers of unconsolidated sediment filling a bedrock trough. The deepest sedimentary unit overlying fractured granitic bedrock is stratified drift. Overlying this unit is a layer of coarse-grained glacial outwash. Above the glacial outwash are finer-grained Quaternary deposits formed by the Rockaway River. The bedrock surface underlying the site has a trough-like morphology. The axis of this bedrock valley trends approximately east-southeast. The observed depth to bedrock ranges from 165 ft. at MW-11d near the former impoundment area to 46 ft. at MW-17d near the river. The bedrock is described as medium to coarse-grained granite and exhibits some horizontal to near-vertical fractures.

The deepest unconsolidated unit encountered at the site is the Pre-Late Wisconsin stratified drift deposit (Qplwg). This unit consists primarily of gray/brown interbedded and sometimes crossbedded coarse to fine sand. The thickness of the unit is controlled by the bedrock topography and by the geometry of the overlying channel deposits and varies from approximately 75 to 125 feet. Textural variations observed in split-spoon samples indicate that this unit is heterogeneous. Since the bedding is generally horizontal, the hydraulic conductivity of this unit is believed to be greatest in the horizontal direction.

Overlying the stratified drift are Rockaway River outwash deposits (Qr). They were deposited in deep channels cut into the underlying stratified drift. These channels are filled with gray, coarse to fine gravel with abundant cobbles and boulders. One main channel deposit extends along a broad zone from MW-5 through RW-3 and MW-13i. Poorly defined channel trends southeast in the vicinity of RW-1. Observations of split-spoon samples collected from these deposits reveal that the grain size, sorting, bedding and other textural features of these deposits are quite variable, indicating that they are heterogeneous.

Finer grained river deposits (Qal) were deposited over the outwash deposits. These river deposits vary from dense gray clay to gravelly sand and they occupy the upper 10 to 15 feet BGS over much of the southeastern portion of the site.

Recent natural gamma-ray logging of wells, when combined with higher-quality borehole descriptive logs, has shown the shallow river deposits to be very heterogeneous. Several silt/clay layers exist in this unit and the shallowest major clay layer is relatively continuous over much of the site. This upper clay layer is truncated by the Rockaway River to the south and varies in thickness from absent in certain locations to approximately 12 feet in thickness near MW-6 and WP-A7. The upper clay layer forms an important low permeability barrier. The upper surface of the upper clay layer is adulatory as is typical of river flood deposits reworked by subsequent river meandering. Coarser silty sands and gravels exist above and below the upper clay layer.

In the vicinity of MW-22, MW-25 and MW-21, the upper clay layer is a gray, very stiff clay. The unit extends northward from MW-6 and crops out along the bottom of the Air Products drainage ditch. Only a very thin (approximately three (3) inches) clay layer was observed at MW-24.

The surface soils in the vicinity of L.E. Carpenter are classified as the Riverhead-Urban Land-Pompton Association. These soils are described in United States Department of Agriculture (USDA, 1976) as deep, well-drained to somewhat poorly-drained, nearly level to strongly sloping gravelly sandy loams, and sandy loams that overlie stratified outwash sand and gravel on outwash plains and terraces. Most of the surface soils at the site have been disturbed by previous mining activities as well as by landscaping activities carried out during the construction of the L.E. Carpenter facility and the adjacent Air Products facility. These soils are mapped as Urban land (Ua). They are mostly well-drained, deep sandy, gravelly material of assorted glacial deposits (USDA, 1976). These soils support an average slope of 1.2% towards the Air Products ditch. Included in this unit are small undisturbed areas of Rockaway, Hibernia, Riverhead, and Boonton soils (USDA, 1976).

The surface soils on the southeastern portion of the L.E. Carpenter property and much of the Wharton Enterprises property, are classified as Whitman (Wm) very stony loam. This soil has a high content of organic matter in the surface layer, contains stones and boulders throughout, and has slow permeability (USDA, 1976). The Hibernia stony loam (HbC) occupies portions of the Wharton Enterprises property and the Air Products property. The ground surface on these properties is generally flat. It features stones and boulders throughout the profile, slow permeability, and moderate to rapid runoff.

The northeastern portion of the L.E. Carpenter property and the northern portion of the Air Products property is occupied by the Ridgebury very stony loam (RgA). The subsoil and generally the surface layers of this unit are as much as 50 percent stones, cobbles, and gravel. It is usually found in low lying areas, such as the former starch drying bed area of the L.E. Carpenter site. It is poorly drained and features moderate to slow permeability (USDA, 1976).

To summarize site geology, the lowermost sedimentary unit above bedrock consists of stratified drift deposits. Higher permeability channel-gravel deposits are incised into these deposits.

Rockaway River Quaternary river deposits overlie these deposits. The uppermost clay layer in the heterogenous Quaternary river deposits is a widespread low-permeability layer.

1.1.2 Hydrogeology

During the remedial investigation, the subsurface hydrogeology of the site was arbitrarily divided into shallow (0 to 30 feet BGS), intermediate (31 to 40 feet BGS) and deep (41 to 170 feet BGS) aquifer zones. Furthermore, in the area of Quaternary river deposits (Qal silt), at 0 to 15 feet BGS, the first groundwater encountered (potentially perched) is referred to as the shallow(a) aquifer zone. This aquifer zone may be hydraulically connected to the Air Products drainage ditch. The intermediate and deep aquifer zones are monitored via wells screened solely within the stratified drift deposits (Qplwg). The shallow aquifer zone(s) are monitored via wells screened across the water table within the Rockaway River outwash deposits (Qr) and/or the Rockaway River river deposits (Qal). The evaluations of the site hydrogeology performed during the course of the Remedial Investigation reveal the following significant hydrogeologic characteristics for the site:

- Within the deep aquifer zone, the horizontal groundwater flow vectors were generally oriented southeast to northwest across the site. The vertical flow vectors were oriented upward between the deep and the intermediate aquifer zones.

- Within the intermediate aquifer zone, horizontal groundwater flow vectors were oriented west to east. The vertical flow vectors are oriented downward between the shallow and intermediate aquifer zones.

- The shallow aquifer zone(s) features a recharge boundary along the Rockaway River, a local recharge zone centered on MW-11s, and a discharge boundary along Air Products drainage ditch. The overall horizontal flow vector orientation is west to east. It is probable that the upper silt/clay unit may act as a semi-permeable divide between the water table and the deeper groundwater. The shallow(a) aquifer zone may be defined as that portion of the groundwater above the upper clay/silt unit.

- These flow patterns carry organic compounds from the L.E. Carpenter site away from the Rockaway River. The low permeability of the upper clay silt/clay in the eastern portion of the site probably restricts significant flow of organic compounds onto the Wharton Enterprises property.

A more detailed discussion of the site specific hydrogeology may be found in the Final Supplemental Remedial Investigation report (WESTON, 1992).

1.1.3 Local Groundwater Usage

Groundwater in the vicinity of the site is not heavily used. In response to a request from NJDEPE for additional information regarding local groundwater usage, a comprehensive well search was conducted which consisted of the following: NJDEPE well permit search; a review of records at local tax offices, water and health departments; telephone correspondence with potential well owners, when possible; questionnaire mailing to owners of potentially active wells not reached by telephone; and site visits to those well locations where records indicated that they were potentially downgradient of the L.E. Carpenter facility and potentially in use.

The well search identified 25 well permits within one (1) mile of the L.E. Carpenter site that were classified as public supply wells, irrigation wells, or domestic wells. Well locations were plotted using the NJDEPE Land Oriented Reference Data System (LORDS) Coordinate System, and where possible, exact locations were verified through comparison with street addresses of the well owners listed on the well search information.

The results of the well search indicated that two of the 25 wells identified are potentially downgradient of the L.E. Carpenter property. Of these wells, the Borough of Wharton Public Supply Well Number Three (New Jersey Well Permit #25-16024) is currently in use and exhibits acceptable water quality. The other potential receptor well is registered to the Shamrock Oil Company (New Jersey Well Permit #25-9366). This company is no longer in business, nor is their well in use. Furthermore, the areal extent of dissolved and immiscible organic compounds in the groundwater at the site has not shown contamination beyond 175 feet east of the property boundary. Based upon their distance from the site (more than 3,300 feet for Shamrock Oil and more than 4,400 feet for Wharton Public Supply Well Number Three) combined with the current knowledge of the areal extent of the groundwater contaminant plume, it is unlikely that the two potential receptors have been impacted by organic compounds emanating from the L.E. Carpenter site.

1.1.4 Flood Plain Delineation

The areal extent of the 100- and 500-year flood plains are depicted on Plate 1 in the Final Supplemental Remedial Investigation (FSRI, WESTON, September 1992). The design of the Washington Forge Pond dam is such that blockage of the spillway would result in spillage over the section of the dam north of the water tower along Main Street. In that event, much of the area north of the Central Railroad Right-of-Way (railroad ROW) would lie within both the 100- and 500-year flood plains. This area is labeled Area A on Plate 1. The topographically elevated bed of the railroad ROW would form a barrier prohibiting floodwater from entering the area labeled Area B on Plate 1. Since much of the Area B is topographically elevated compared to the Rockaway River bed, this area would be unaffected by floodwater emanating from the main channel of the river. Therefore, most of Area B lies outside the 100- and 500-year flood plains. Only the eastern perimeter of this area (i.e., the strip along the Wharton Enterprises property boundary and along the Air Products drainage ditch) lies within both the 100- and 500-year flood plains. The Wharton Enterprises portion of the site lies within both the 100- and 500-year flood plains.

1.2 SITE HISTORY

The site is located within the Dover Mining District, which is one of the oldest mining districts in the country. Iron ore was extracted from three mines in the vicinity of the site from the late 1800s to the early 1900s. The Washington Forge Mine and the West Mount Pleasant Mine were located directly on what is currently the L.E. Carpenter property (Sims, 1958). The Washington Forge Mine was located in the approximate area of Building 16. The West Mount Pleasant Mine was located approximately 170 feet northeast of the Washington Forge Mine, in the general vicinity of Building 15. The Orchard Mine was located on the southern side of the Rockaway River, approximately 200 feet south of the Washington Forge Pond. The Washington Forge and West Mount Pleasant mines operated intermittently between 1868 and 1881. The Orchard Mine was operated intermittently between 1850 and 1910. Tailings from the Washington Forge and West Mount Pleasant mines are thought to have been disposed of on site. A forge which serviced these and other local mines was operated at the Orchard mine site. Shipment of ore from and through the site may have adversely affected soil and groundwater quality.

The L.E. Carpenter facility was involved in the production of Vicrtex vinyl wall coverings from 1943 to 1987. The production of vinyl wall coverings involves several manufacturing processes which were carried out in the various buildings comprising the L.E. Carpenter facility. Upon delivery to the facility, rolls of virgin cotton cloth were washed (desized) to remove starch and cotton particles. The first step in the manufacturing process is referred to as lamination. Lamination involves the bonding of fabric to the vinyl film using a plastisol adhesive in conjunction with heat and pressure. The fabric/film laminate is then coated with a plastisol compound in order to texturize the material in preparation for printing. The printing process involves the application of decorative print patterns and/or protective topcoat finishes. When printing is completed, the product is inspected and packaged for shipment to the consumer. The facility was originally heated by coal and later converted to #6 fuel oil.

The manufacturing processes involved the generation of non-hazardous starch water, waste solvents including xylene and methyl ethyl ketone, the collection of solvent fumes via "smog-hog" condensers, the collection of particulate matter via a dust collector, and the discharge of non-contact cooling water to the Rockaway River. During the period of operation, the L.E. Carpenter facility was operated in accordance with prevailing waste disposal regulations and environmental statutes. The facility operated several air pollution control devices permitted by NJDEPE and maintained a New Jersey Pollution Discharge Elimination System (NJPDES) Permit for the discharge of non-contact cooling water. From approximately 1963 until 1970, L.E. Carpenter disposed its wastes, including a polyvinyl chloride (PVC) waste material, into an unlined on-site impoundment.

In response to sampling efforts conducted by the NJDEPE in 1980 and 1981, L.E. Carpenter and NJDEPE entered into an ACO in 1982, which required L.E. Carpenter to:

- Remove the waste sludge from the unlined surface impoundment.

- Define the full extent of chemical compounds floating on the groundwater.
- Decontaminate the groundwater beneath the site as follows:
  - Remove the immiscible chemical compounds from the groundwater.
  - Remove dissolved volatile organic compounds (VOC), including hazardous substances from the groundwater beneath the site.
- Monitor groundwater quality according to the following schedule:
  - Collect samples to be analyzed for specific VOC every two months for a six-month period beginning on or about June 1982 and quarterly thereafter.
  - Take measurements every month to determine groundwater flow direction(s) and the thickness of the free floating organic compounds floating upon the groundwater.

On 24 February 1983, an Addendum (1983 Addendum) was added to the 1982 ACO to clarify its provisions.

Pursuant to the requirements of the 1982 ACO and the 1983 Addendum, L.E. Carpenter took the following actions: in April and May 1982, L.E. Carpenter removed over 4,000 cubic yards of waste from the surface impoundment and thereafter implemented a groundwater quality monitoring program. On 11 May 1984, L.E. Carpenter initiated removal of the immiscible chemical compounds from the top of the water table beneath the site using a passive recovery system.

On 26 September 1986, an additional ACO was entered into which superseded the 29 January 1982 ACO and the Addendum of 24 February 1983, except all requirements of the Groundwater Decontamination Plan dated 31 October 1983, as approved with conditions by NJDEPE on 26 January 1984 were incorporated. Under the terms of the Amended 26 September 1986 ACO, L.E. Carpenter initiated a RI/FS of its former manufacturing facility in Wharton, New Jersey.

The active production of vinyl wall coverings ceased in 1987. Since that time, the portion of the facility east of the railroad tracks has been inactive. Access is currently restricted to the area east of the railroad track by an eight-foot chain-link fence. The buildings west of the railroad tracks have been subleased as warehouse space and manufacturing operations.

1.3 SITE CLEANUP ACTIVITIES

This subsection of the report will summarize the investigative and remediation activities completed to date as well as provide a chronology of documents previously submitted to the NJDEPE.

Several site investigation and remediation activities have been completed. Table 1-1 provides a chronology of major investigation and remediation efforts. In 1982, L.E.Carpenter removed 4,000 cubic yards of sludge and soil from the former surface impoundment. The starch drying beds were excavated and backfilled. Since May 1984, more than 5,000 gallons of floating product has been recovered from a series of recovery wells located primarily on the eastern side of the site. In 1991, the existing groundwater recovery system was upgraded and three additional recovery wells were installed in order to enhance the removal of the immiscible product. Product recovery rates increased ten-fold with the additional recovery wells and a more efficient skimmer system.

In 1989, an extensive asbestos removal was completed in Buildings 12, 13, and 14. All underground and inactive aboveground storage tanks were decommissioned and removed from the facility in 1990 and 1991. The underground storage tanks were closed in accordance with procedures established by the NJDEPE Bureau of Underground Storage Tanks (BUST) under an approved tank closure plan (August 1990).

All drummed raw materials have been removed from the site. In September 1991, process piping, tanks and appurtenances in Building 13 were decontaminated and disposed of off site and Building 9 interior was decontaminated. In December 1991, Buildings 12 (former boiler house), 13, and 14 were razed.

The initial RI was completed in 1989. The SRI was completed in 1990 and several additional focused investigations were completed in 1991. Each investigation resulted in a submittal to NJDEPE. The Final Supplemental RI report presented and summarized the findings of the investigative efforts completed since the submittal of the SRI. The Final SRI was submitted and accepted by NJDEPE in September 1992. A chronology of document preparation is presented in Table 1-2.

1.4 FINDINGS OF THE REMEDIAL INVESTIGATION

The RI field effort was initiated in February 1989. The Draft Report of RI Findings and the Revised Report of RI Findings were submitted to NJDEPE in November 1989 and June 1990, respectively. A report summarizing the findings of the Supplemental RI sampling effort, which was conducted in response to NJDEPE requests, was submitted to NJDEPE in November 1990. NJDEPE requested additional investigations during 1991. Various field efforts were completed and reported to NJDEPE as each was completed. A Final Supplemental Remedial Investigation Report was presented in September 1992 which summarized the findings of these investigative efforts undertaken since the SRI submittal in 1990.

A primary focus of the RI was the determination of the extent of contamination related to the former on-site waste impoundment. The RI included a soil gas survey, surface and subsurface soil sampling, sediment sampling, surface water sampling, and groundwater sampling.

A soil gas survey indicated the presence of ethylbenzene, xylene, toluene, and naphtha-related compounds in several areas on site. These data points were used to identify test pit and hand-auger sampling locations.

The soil investigation, consisting of test pit and hand auger sampling, indicated base neutral (BN) compounds in the areas of the former impoundment and tank farm, starch drying beds, and condensate tanks from the "smog hog" air pollution control system (designated E-5 through E-

8). The BN compound detected at the highest concentration was DEHP. The soil investigation confirmed contamination from volatile organic compounds (VOCs), primarily ethylbenzene and xylene, in the vicinity of the former impoundment and tank farm. Several isolated areas of elevated metals concentrations, primarily lead and antimony, were identified. Low levels of polychlorinated biphenyls (PCBs) which were detected in the area of the former starch drying beds, meet the criteria for compliance with the proposed New Jersey soil cleanup standards. PCBs were detected on the Wharton Enterprises Property at concentrations less than the New Jersey hazardous waste limit (50 mg/kg), but greater than concentrations which comply with the proposed New Jersey soil cleanup standards. The highest PCB concentration detected on the Wharton Enterprises property was 45 mg/kg, whereas the starch drying beds it was 2.9 mg/kg.

The source of the PCBs is not known. PCBs detected on the off-site Wharton Enterprises property may be attributable in part to electrical utility lines shown in this location in historical site maps and aerial photographs.

Groundwater flow patterns and the extent of groundwater contamination are discussed in depth in Section 4.3 of the Final Supplemental RI (WESTON, 1992). Consistent with historical measurements, shallow groundwater is flowing in a northeasterly direction and is discharging to the drainage ditch. The Rockaway River, adjacent to the site, has consistently acted as a recharge zone. Intermediate groundwater, as well, is flowing in a northeasterly direction.

The areal extent of groundwater contamination is presented in Figures 1-3 and 1-4, both of which have been generated using Krigging techniques and therefore exaggerate existing conditions. Contamination originating from L.E. Carpenter in the shallow groundwater zone is bounded by the Air Products drainage ditch to the north and MW-25 to the east. No contamination has been detected in the intermediate or deep aquifer zones, with the exception of MW-11i. MW-11i is located in the center of the immiscible product plume. Contaminants were consistently detected in the initial round of sampling and greatly reduced in the second, thus suggesting that the contamination was due to "carry down" from the drilling methods. NJDEPE has requested that additional well(s) below the clay layer be installed downgradient (on the Air Products property) during the Remedial Design stage of the project to confirm there is no contaminant migration onto Air Products property.

Surface water samples collected from the Rockaway River, the drainage ditch, and Washington Forge Pond did not contain elevated levels of VOCs, BNs, or metals; however, one sample from the drainage ditch on the Air Products property contained low levels of xylene. The holding time for selected volatile organic analysis of surface water samples collected during the original Remedial Investigation was exceeded; therefore, the conclusions drawn from the use of those data points are qualified. Subsequent river water sampling conducted in August 1992 confirmed no detectable levels of contaminants in the Rockaway River. Furthermore, the ecological assessment of the Rockaway River concluded that there is no impact on the river from the L.E. Carpenter site.

WESTON evaluated all of the sediment sampling results in light of background data collected by USGS (Smith, Harte, and Hardy, 1987). The background data collected during the RI and SRI are consistent with those concentrations of compounds found in sediments in the USGS data. Sediment contaminants are localized in those areas adjacent to the site and immediately downgradient of former discharge pipes. Locations downstream of the facility have not been impacted by L.E. Carpenter as evidenced by concentrations of constituents similar to background levels.

Analysis of monthly ambient air samples collected from four locations across the site between February and November 1989 did not detect levels of VOCs or metals in excess of OSHA permissible exposure levels.

1.4.1 Post-Remedial Investigation Studies

Two field efforts were undertaken after submittal of the Final Supplemental Remedial Investigation report in September 1992. A total of 23 well points were installed on the site from January 6 through 8 and February 3 and 4. Figure 1-5 depicts the location of the well points installed at the site. The well points centered around three areas of known and suspected product presence: MW-1, MW-11s and MW-12s. Well points WP-A1 through WP-A9 were installed to further delineate the extent of free product downgradient of MW-1. Well points WP-B1 through WP-B10 were installed to further delineate the extent of free product in the vicinity of MW-11s. Well points WP-C1 through WP-C4 were installed to delineate the extent of the product in the vicinity of MW-12s. All well points were numbered in order of installation. The depths of the well points range from 11 feet to 17 feet. Each well point was constructed of 2-inch PVC with 10 feet of 0.020 inch PVC screen. WP-B4, WP-B6, and WP-B7 were installed with 9 feet of screen each. A filter pack of #2 moire sand, bentonite seal and grout cap were added to each well point. Each well point was also equipped with a locking well cap. Protective casings were installed only where danger of vehicle movement existed and on flush mounted well points.

Two of the well points (WP-B7 and WP-B8) were installed on the Wharton Enterprises property between the Air Products drainage ditch and the Rockaway River as requested by the NJDEPE. The third location suggested by the NJDEPE, between RW-2 and MW-14s next to the ditch, was not accessible due to dense vegetation and the fence. The close proximity of MW-14s allows adequate monitoring of floating product at that specific location.

The well points are utilized for product thickness measurements and groundwater elevation measurements. Product thickness measurements conducted since the well points were installed indicate the floating product layer is an elongated oval shape, trending roughly east-west. Two "pods" of thicker product center around the MW-11 cluster and around WP-A4. The C-series of well points, installed around MW-12s, indicate that the extent of the oil-type product layer is very limited in size, and is not continuous with the product plume centering around MW-11s. Figure 1-6 presents the results of recent product thickness measurement in wells and well points.

In order to develop a better understanding of site stratigraphy, a natural gamma-ray logging program was completed on selected groundwater monitoring wells and well points during March 1993. As shown on Table 1-3, 34 wells were logged with natural gamma-ray techniques. These wells included older monitor wells with poor descriptive logs, newer monitor wells with accurate descriptive logs (for calibration purposes), and most of the temporary well points. In this study, the logs were used only for qualitative interpretations.

The down-hole gamma-ray log is a continuous vertical measurement with respect to depth of the radioactivity of the rock units in a borehole or well. The radioactivity occurs most commonly as a result of the decay of naturally radioactive isotopes of potassium-40 and the daughter products of uranium-235 and thorium-232. These isotopes are relatively more abundant in the fine-grained fraction of sedimentary rocks than in the coarser fractions. The total radiation intensity varies predictably with lithology or rock type. Clays or shales normally exhibit the highest radioactivity while unconsolidated sands, sandstones, and quartzites show the least. Exceptions to these generalities occur, and a knowledge of local geology is necessary for confident log interpretation. Gamma-ray logging in existing wells is often an efficient way to collect lithologic information where descriptive logs are poor or do not exist.

The order of logging proceeded from wells with no floating product present to those with increasing thicknesses of floating product present. The probe was decontaminated between logs with an Alconox wash and a high-pressure hot-water rinse with potable water. For quality assurance purposes, logs were repeated occasionally in the same hole in order to verify equipment operation. The repeat log runs yielded reproducible results. Major gamma radiation peaks were identified on the geophysical logs. The depths of occurrence of these peaks were compared with clay intervals recorded in descriptive lithologic logs. (The depth resolution of the gamma-ray peaks is about 1.5 feet.) Only a few wells had both a gamma-ray log and a complete descriptive log of good quality, but clays noted in the descriptive lithologic logs were detected by the gamma-ray log in every case.

More clay was observed on the gamma logs than was recorded in the older, poor quality descriptive logs. Based on the gamma-ray logs, clays or silts were present in all but three or four of the wells that were logged. As shown in Table 1-3, up to three clay units were identified in some of the deeper holes. The interpretation of gamma signatures was based on the correlation with descriptive logs and general experience.

The new gamma log data, when combined with descriptive well log data and test pit data gathered during the Remedial Investigation, indicates that the upper clay is relatively continuous across most of the site, but is truncated to the north and south. Figure 1-7 depicts the elevation of the top of the upper clay. The undulatory surface of the upper clay and its variable thickness (truncated to the north and south) are typical of river flood deposits reworked by subsequent river meandering.

The greatest concentration of free product generally occurs in the vicinity of the MW-11 cluster and corresponds to a topographic low at the top of the upper clay. The greatest thickness of clay also trends northeast-southwest beneath the same area. The combination of a topographic low and a relatively thick clay section (8-12 feet) serves to trap the free product and keep it from moving laterally and vertically.

1.5 FINDINGS OF THE BASELINE RISK ASSESSMENT

A baseline RA (WESTON, 1992) was performed for the L.E. Carpenter site based on the RI data. The main objective of the RA was to provide a basis for determining levels of contaminants that can remain on site and still be adequately protective of public health. The RA evaluated the potential risk to humans or the environment under present use and hypothetical future use in the absence of remedial measures at the site. The RA is then used to determine the need for remediation and, if action is warranted, to aid in selection of remedial alternatives in the FS. Remedial goals are to be developed based on calculated risk for potential carcinogenic and non-carcinogenic health effects occurring under each exposure scenario.

Conservative assumptions were used to provide an estimate of potential risks to humans via air, groundwater, soil, sediment, surface water, and fish ingestion pathways. The potential exposure scenarios and related pathways are summarized in Table 1-4.

Superfund guidance recommends that carcinogenic risks exceeding the range of 10^{-4} to 10^{-6}, and hazard indices exceeding 1.0, be further evaluated. A hazard index (HI) is the ratio of the site average or maximum concentrations to a reference dose established for that chemical.

Soil exposures were assumed to include incidental ingestion, inhalation of airborne dust particulates, and dermal absorption. Groundwater exposures were assumed to include ingestion, as well as inhalation and dermal absorption during showering. Surface water and sediment exposures were assumed to include incidental ingestion and dermal absorption. Air inhalation and ingestion of fish from the Rockaway River were also considered.

As noted in part below, the foregoing exposure scenarios are hypothetical. They do not reflect present or actual exposure conditions at the site, which is fenced to prevent trespassing, poses little if any prospect for direct contact with soils by current on-site workers, is not associated with large volume continuous fish consumption or wading/swimming, and will be subject to a deed restriction to preclude residential development. In addition, there are currently no human receptors of groundwater at the site.

The ecological risk assessment of the Rockaway River did not identify any water contaminants which exceeded ambient water quality criteria (AWQC). Sediment concentrations were conservatively compared to the National Oceanic and Atmospheric Administration (NOAA) Effect Range-Low (ER-L) value, which represents the lower one-tenth percentile of a range of sediment concentrations in which any biological effects had been observed at other sites. Due to the conservative nature of this test, the concentrations of many contaminants in upgradient and downgradient samples exceeded the ER-L value. The PAH compounds anthracene, dibenzo(a,h)anthracene, fluorene, phenanthrene, and pyrene, as well as antimony exceeded their respective ER-L values by more than an order of magnitude.

1.6 USE OF RISK ASSESSMENT IN DIRECTING REMEDIAL MEASURES

In order to focus remedial measures on key potential pathways that pose a potentially realistic risk, contaminants detected on site, pathways, and exposure assumptions that produced the greatest risks during the initial risk assessment were re-evaluated and refined. The following subsections discuss specific matrices and exposure pathways reviewed.

The L.E. Carpenter Baseline Risk Assessment, which was performed in accordance with the Risk Assessment Guidance for Superfund (RAGS), was used as a starting point to identify the contaminants that require remediation. Subsequently, the concentrations of these contaminants were compared to NJDEPE Cleanup Standards, which are available for soil and groundwater. The proposed NJDEPE Cleanup Standards specify criteria to determine compliance with soil standards. These criteria include such items as: (1) the arithmetic mean of a constituent in samples collected from an area of concern is numerically less than the associated standard; (2) no more than ten percent of the samples exceed the cleanup standard for each chemical constituent; and (3) no single soil sample exceeds its applicable soil standard by a factor of ten (for standards less than or equal to 10 ppm), five (for standards between 10 and 100 ppm), or two (for soil standards greater than 100 ppm). Also taken into consideration were the frequency of detection and the likelihood that the contaminant is site-related and not from blank contamination or upgradient/regional sources. Based on this evaluation, the chemicals that drive remediation for each media are identified below.

1.6.1 Air

Air concentrations were below OSHA limits, except for lead during one three-month period (off-site sources (such as automobile exhaust) are likely major contributors to airborne lead). Therefore, air will not specifically be addressed by remedial measures. However, potential sources of air contamination due to surface soil may be addressed via soil cover, removal, or treatment.

1.6.2 Soil

Estimated risk levels presented in the RA were used to identify the primary soil contaminants. Potential risks due to exposure to soil contaminants results from ingestion of, inhalation of, or dermal contact with the soil. Exposure via each of these potential pathways would be eliminated if direct contact with the soils was prevented. The present indoor operations of the tenants at the site and any probable future use scenarios do not create a significant risk of direct soil contact by on-site workers, and the site is fenced to prevent trespassing.

If contact with the contaminated soil is not precluded, specific locations on site would have to be remediated. Hypothetical future residential use (using 95% limit concentrations) resulted in estimated carcinogenic risks exceeding 10^{-6} or HI exceeding 1.0 for DEHP, Aroclor 1254, methylene chloride, benzene, ethylbenzene, five PAHs, antimony, and chromium (assuming hexavalent). Ninety percent of the carcinogenic risk was attributable to DEHP, which was found in approximately 90% of the soil samples collected.

However, based on the historical industrial use of the site, nonresidential use scenarios are more appropriate for estimating potential risks and identifying soil areas requiring remediation. To ensure nonresidential use of the site in the future, a deed restriction is being proposed (see Subsection 4.2.2). The most conservative nonresidential exposure scenario is relative to an on-site worker. Contaminants with estimated carcinogenic risks exceeding 10^{-6} or HI exceeding 1.0 (using 95% limit concentrations) under non-residential use were DEHP, Aroclor 1254, methylene chloride, benzene, and five PAHs. Only DEHP exceeded a carcinogenic risk of 10^{-4}. Therefore, the remediation of soil contaminated with DEHP will be considered in this FS.

The arithmetic average concentration of Aroclor 1254 did not exceed the draft NJDEPE Nonresidential Cleanup Standard for PCBs of 2 mg/kg, or the draft NJDEPE Residential Cleanup Standard for PCBs of 0.49 mg/kg. However, the maximum concentration on the Wharton Enterprises property (45 mg/kg) exceeded the standard. Therefore, remediation of PCBs soil hot spots on the Wharton Enterprises property will be pursued. If the property in question is subject to a deed restriction at the time of remediation, the proposed cleanup standard for PCBs of 2 mg/kg (in association with a deed restriction) will be utilized. If the property is not subject to a deed restriction at the time of remediation, the residential surface soil proposed cleanup standard of 0.49 mg/kg will be utilized.

Methylene chloride may be attributable to some extent to laboratory contamination since it was commonly detected in blank samples. Methylene chloride was also detected in samples of fill material collected from the disposal area. The arithmetic average concentration (15.9 mg/kg) of methylene chloride in soil samples was below the draft NJDEPE Nonresidential Cleanup Standard (210 mg/kg) and the maximum concentration (310 mg/kg) did not exceed the two times the standard. Therefore, remediation of methylene chloride contaminated soils will not be considered in this FS.

Benzene was detected in only 6 of 97 soil samples. The arithmetic average concentration of benzene (2.85 mg/kg) was below the draft NJDEPE Nonresidential Soil Cleanup Standard (13 mg/kg), and the maximum concentration (34 mg/kg) did not exceed the five times the standard. Therefore, remediation of benzene in site soils is not required according to the draft NJDEPE Cleanup Standards.

For each of the five PAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthrene/benzo(k)fluoranthrene, chrysene, and indeno(1,2,3,c,d)pyrene) the arithmetic average concentrations did not exceed the respective draft NJDEPE Nonresidential Soil Cleanup Standard, and maximum concentrations did not exceed ten times the standard. Therefore, remediation of PAHs from site soils will not be considered in this FS.

Toxicity values are not available to calculate risks due to lead, which was found in every soil sample collected, including background samples. Its presence is due in part to the use of mine tailings for on-site fill material and from regional anthropogenic sources. However, since several hot spots of lead were detected, remediation of lead hot spots which exceed the proposed draft NJDEPE Nonresidential Soil Cleanup Standard of 600 mg/kg will be included in this FS.

The 95% confidence limit for antimony did not exceed a Hazard Index 1.0 for any non-residential use scenario. Antimony has been associated with iron mining spoils. However, isolated hot spot remediation for antimony will be pursued. The maximum soil concentration of antimony (828 mg/kg) exceeded the draft NJDEPE Nonresidential Cleanup Standard (340 mg/kg) by more than a factor of two. Most of the antimony hot spots coincide with the lead hot spots.

Plate 1, Locations of Elevated Metals Concentrations in Soils (Hot Spots), graphically depicts the locations where lead and/or antimony concentrations exceeded their respective cleanup goals of 600 mg/kg and 340 mg/kg in site soils. Areal extent of these hot spots was estimated at 30 feet squared, but actual extent will be determined by further sampling and analyses (i.e., post excavation sampling) during remediation.

1.6.3 Sediment

No chemicals were detected in Rockaway River sediments at levels exceeding a 10^{-6} average lifetime risk or a HI of 1.0 The 95% maximum carcinogenic risks for four PAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthrene/benzo(k)fluoranthrene, and chrysene) were each between 1.0×10^{-6} and 2.1×10^{-6}. In addition, anthracene, dibenzo(a,h)anthracene, fluorene, phenanthrene, pyrene, and antimony exceeded their respective environmental Effect Range - Low (ER-L) values as noted in the RA. The PAHs are thought to be ubiquitous in historically industrial areas and probably originated from coal storage and usage at upgradient and nearby locations. Antimony most likely originated from a variety of sources, including mine tailings and their use as fill on the site, upgradient sources, and on-site manufacturing operations.

L.E. Carpenter conducted an ecological assessment of Rockaway River sediments in September 1992. In that assessment, the structure of the benthic macroinvertebrate community of the Rockaway River was quantified in terms of taxonomic diversity, numerical abundance and function and evaluated in light of biotic and abiotic environmental variables. The study indicated that the chief deterministic factors driving the distribution and abundance of benthic macroinvertebrates in the study area 1 is the quality of the habitat as it relates to resource availability. Evidence of adverse ecological effects resulting from contaminants detected in the sediment were not observed in the Rockaway River adjacent to the L.E. Carpenter site or in any portion of the Rockaway River studied. The historical operations on site and current conditions of the site are not impacting the biological community in the sediment or water environments of the Rockaway River. The Ecological Assessment report concluded that remediation efforts specific to Rockaway River sediments or surface water do not appear warranted. In a letter from NJDEPE Bureau of Federal Case Management to L.E. Carpenter and Company dated 3 February 1993, NJDEPE and U.S. EPA agreed with this conclusion.

1.6.4 Surface Water

No contaminants in the Rockaway River water exceeded a 10^{-6} average or 95% limit risk range or an average HI of 1.0. Lead was found in one sample (87.2 ug/L) above the quantification limit, in one sample below the quantification limit, and was not detected in a third sample. Lead was also found in the sample upstream of the site at 20.7 ug/L. Both the upstream and downstream concentrations exceeded Ambient Water Quality Criteria (AWQC). It appears that lead is ubiquitous throughout the area due to vehicle exhaust and other anthropogenic sources.

1.6.5 Fish

The only contaminant exceeding either a 10^{-6} average or 95% limit risk, or an average or 95% limit HI exceeding 1.0 due to consumption of fish from the Rockaway River was arsenic. Fish samples were not analyzed; instead, concentrations of the substances found in water were partitioned into fish through the use of bioconcentration factors. Human ingestion of a defined quantity of fish was then assumed. This approach results in a very conservative overestimation of risk. Arsenic was not found above the quantification limit in any of the three surface water samples from the Rockaway River; estimated (J) values for two of the samples were evaluated in the RA. Based on the available information and very conservative nature of the evaluation, control of fish ingestion does not appear warranted.

1.6.6 Groundwater

Although there are currently no human receptors of on-site groundwater, hypothetical residential use of groundwater was evaluated in the RA since the groundwater is considered to be Class IIA. Contaminants that resulted in estimated carcinogenic risks exceeding 10^{-6} or HI exceeding 1.0 (using 95% limit concentrations) in shallow groundwater were DEHP, methylene chloride, ethylbenzene, xylenes, arsenic, and antimony. Four chlorinated solvents (1,1-dichloroethane, 1,1-dichloroethene, tetrachloroethene, and trichloroethene) also exceeded these levels but were detected in an off-site well (MW-13s) only. This well is not hydraulically downgradient of the site and the solvents are not thought to be associated with L.E. Carpenter manufacturing operations. Therefore, groundwater remediation options will not be designed to address chlorinated solvents.

The maximum DEHP concentration in shallow groundwater (62 mg/L) exceeded the NJDEPE Groundwater Quality Criteria (0.03 mg/L) by more than an order of magnitude. Groundwater remediation will focus on removal of this compound.

Methylene chloride was detected in only 5 of 30 shallow groundwater samples at concentrations significantly greater than blank samples, and greater than the NJDEPE Groundwater Quality Criteria of 0.002 mg/L. However, the presence of methylene chloride in blank samples renders its detection in groundwater samples suspect. Given the low frequency of confirmed detection, remediation of groundwater specifically for methylene chloride will not be pursued. However, remedial measures designed to address the volatile organics in groundwater will also address methylene chloride, if present.

Ethylbenzene was detected in 22 of 30 shallow groundwater samples, and its maximum concentration (26 mg/L) exceeded the NJDEPE Groundwater Quality Criteria (0.70 mg/L) by more than ten times. Therefore, groundwater remediation will address removal of this compound.

Xylenes were detected in 13 of 30 shallow groundwater samples. Its maximum concentration exceeded the NJDEPE Groundwater Quality Criteria (0.04 mg/L). Therefore, groundwater remediation will address removal of this compound.

Arsenic was detected in 10 of 30 shallow groundwater samples. Its maximum concentration (0.032 mg/L) exceeded the NJDEPE Groundwater Quality Criteria of 0.008 mg/L. However, the slightly elevated concentrations are believed to be associated with the mine spoils deposited at the site, as well as with natural background levels. No elevated arsenic levels were found in site soils, so the metal does not appear to be site related.

Antimony was detected in 5 of 30 shallow groundwater samples, three of which contained concentrations below the prevailing quantification for antimony at the time of analysis (0.05 mg/L). The maximum concentration exceeded the NJDEPE Groundwater Quality Criteria of 0.02 mg/L. The maximum concentration of antimony (0.54 mg/L) was detected in MW-12s during Round 1 sampling. However, the concentration during Round 2 in this well decreased significantly to just over the Round 1 quantification limit (0.075 mg/L). Antimony is thought to be a component of the ore in the Dover mining district and may in large part be the result of the previous mining operations. Antimony is one of a number of cations which are common and stable in sulfide ores associated with iron ores. For these reasons remediation of groundwater specifically for antimony will not be pursued. However, a groundwater treatment system designed for contaminant removal will include a treatment alternative for those metals detected at concentrations above the groundwater cleanup standard. Determination of the need for this option will be deferred until Remedial Design, at which time pilot studies will determine the expected influent and effluent metals concentrations for the proposed system.

In intermediate groundwater, using 95% limit concentrations and hypothetical residential exposure, DEHP and arsenic exceeded 10^{-6} carcinogenic risk levels and exceeded a HI of 1.0. DEHP was detected in only two of 14 samples; one well during one round of sampling at a concentration which exceeded the proposed cleanup standard, and in another well during one round of sampling at a concentration below both the proposed cleanup standard and the limit of quantitation. Arsenic was detected in only 1 of 14 samples at a concentration equal to the quantitation limit. For these reasons, intermediate zone groundwater will not be considered in this FS. However, remediation measures to address shallow groundwater will favorably impact the intermediate groundwater zone.

In deep groundwater, using 95% limit concentrations and hypothetical residential exposure, DEHP and 1,2-dichloroethane (1,2-DCA) exceeded 10^{-6} carcinogenic risk levels and/or a HI of 1.0. Each compound was detected in only one of 10 deep groundwater samples. 1,2-DCA was detected as a J-value at one-third the quantification limit and was below the proposed NJDEPE Groundwater Cleanup Standard. The DEHP concentration in MW-11d exceeded the standard during one round of sampling but was not detected in another. Detection of this compound in one out of 10 deep groundwater samples does not warrant cleanup for the entire site. Therefore, deep groundwater will not be considered in the FS.

1.6.7 Contaminants to be Addressed in Feasibility Study

Based on the preceding analysis, the media and contaminants to be addressed by the FS are presented in Table 1-5. It is important to note that in many cases, constituents in addition to these will be addressed by application of many of the proposed remedial actions. For example, covering portions of the site would remediate the risk of contact with all soil contaminants.

Groundwater and soil treatment techniques would be effective for many contaminants, not just those listed. These contaminants are, however, the primary drivers for the remedial alternative evaluations for the L.E. Carpenter site.

1.7 CONCEPTUAL SITE MODEL

Conceptual site models qualitatively describe a site and its features and present hypotheses regarding potential or suspected sources, the contaminants present, affected media, and routes of migration. The site model is critical in evaluating exposure scenarios and potential impact on receptors in the risk assessment. The site model attempts to put the potential environmental concerns in clearer focus so that the objectives of the data collection and remediation efforts during the RI/FS are well defined and directed towards those operable units which potentially pose actual risks.

The conceptual site model discussion is divided into the following segments:

- Sources
- Contaminant migration
- Potential receptors

1.7.1 Known or Potential Contaminant Sources

Contaminants have been or may have been released from a variety of sources at the site. The identified sources include:

- An unlined surface impoundment
- Process discharges
- Raw material storage
- The former tank farm area and other USTs

SECTION 2.0

APPLICABLE OR RELEVANT AND APPROPRIATE ENVIRONMENTAL AND PUBLIC HEALTH REQUIREMENTS (ARARs)

2.1 IDENTIFICATION OF ARARs

The National Contingency Plan (NCP), revised 8 March 1990 (40 CFR 300), and SARA provide that the development and evaluation of remedial actions under CERCLA must include a comparison of alternative site responses to applicable or relevant and appropriate federal and state environmental and public health requirements (ARARs).

In accordance with the requirements of the NCP, the remedial action selected must meet all ARARs unless a waiver from specific requirements can be granted. The seven conditions (SARA Section 121; CERCLA Section 121(d)(4)) for a possible waiver are summarized as follows:

- The remedy under consideration is only an interim remedy and is not the final or permanent remedy selected for the site.
- Compliance with such standards would create greater risks to public health than the benefit it would provide.
- Compliance with such standards is "technically impractical".
- A different remedy exists that provides public health protection "equivalent" to the preferred cleanup standard.
- A more stringent state standard, which would otherwise be applicable, has not been consistently applied to other sites in the state.
- Compliance with an applicable state requirement would effectively result in the statewide prohibition of land disposal of hazardous substances.
- The cost of the remedy is too expensive, considering the other demands on the fund.

Identification of ARARs must be performed on a site-specific basis. The NCP and SARA do not provide across-the-board standards for determining whether a particular remedial action will produce an adequate remedy at a particular site. Rather, the process recognizes that each site will have unique characteristics that must be evaluated and compared to those applicable and relevant requirements that apply under the given circumstances. ARARs are defined as follows:

- Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal, state, or local law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site.

- Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal, state, or local law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at a CERCLA site.

For remedial actions performed under SARA, permits for compliance with relevant and appropriate regulations for on-site remedial actions are not required. However, CERCLA and SARA do require that the selected alternative meet relevant and appropriate regulatory standards or performance levels where possible, even though a permit is not required.

ARARs may be divided into the following categories:

- Chemical-specific requirements are health- or risk-based concentration limits or ranges in various environmental media for specific hazardous substances, pollutants, or contaminants. These limits may take the form of action levels or discharge levels.

- Location-specific requirements are restrictions on activities that are based on the characteristics of a site or its immediate environment. An example would be restrictions on wetlands development.

- Action-specific requirements are controls or restrictions on particular types of activities in related areas such as hazardous waste management or wastewater treatment. An example would be RCRA incineration standards.

In addition to legally binding laws and regulations, many federal and state environmental and public health programs also develop criteria, policies, guidance, and proposed standards that are not legally binding. However, they may provide useful information or recommended procedures. These materials to be considered, or TBCs, are not potential ARARs but are evaluated along with ARARs.

2.2 CHEMICAL-SPECIFIC REQUIREMENTS

"Chemical-specific requirements set health or risk-based concentration limits or discharge limitations in various environmental media for specific hazardous substances, pollutants, or contaminants" (52 FR 32496). These requirements generally set protective cleanup levels for the chemicals of concern in the designated media or indicate a safe level of discharge that may be incorporated in a remedial activity. Chemicals identified in the Remedial Investigation/Risk Assessment as being present at the site are included in the following tabulations of chemical specific numerical standards.

2.2.1 Groundwater Standards

National Interim Primary Drinking Water Standards established under the Federal Safe Drinking Water Act (FSDWA) are promulgated as MCLs, which represent the maximum allowable levels of certain contaminants in public water systems. Interim health-based MCLs have been established by EPA for those organic and inorganic chemicals listed in Table 2-1.

In addition, the New Jersey Safe Drinking Water Act (NJSWDA) and A-280 Amendments set MCLs for drinking water in the state (Table 2-1). Groundwater in the vicinity of the site is a potential source of drinking water and is located in the boundaries of a Class IIA groundwater. Therefore, MCLs are regarded as applicable requirements for the L.E. Carpenter site since the local groundwater has been impacted and the floating product layer and existing soil contamination could potentially further impact groundwater. There are no current local receptors and public water is provided and available to users/residents in the area of the site. Applicability is based on a future use scenario, and the potential for off-site transport of contaminants.

The State of New Jersey has also promulgated groundwater discharge requirements under the New Jersey Pollutant Discharge Elimination System (NJPDES) and promulgated chemical specific groundwater quality criteria for Class II-A groundwater under N.J.A.C 7:9-6 et. seq.. Standards for groundwater classification IIA, which includes groundwater in the vicinity of the L.E. Carpenter site, are also presented in Table 2-1. The levels set by these standards will be the main factor used to determine site-specific discharge criteria.

Site specific groundwater discharge criteria for the L.E. Carpenter site are presented in Table 2-2. In addition, interim site specific groundwater discharge criteria have been developed for the L.E. Carpenter site. These criteria will be monitored for during the initial phases of groundwater discharge. Upon determination that groundwater discharge has met the criteria for these compounds consistently over three monitoring periods, these criteria will no longer be monitored for. Interim groundwater discharge criteria are presented in Table 2-3.

2.2.2 Ambient Water Quality Criteria (AWQC)

Federal AWQC documents have been published for 65 pollutants listed as toxic under the Clean Water Act. These criteria are unenforceable guidelines that may be used by states to set surface water quality standards. Although these criteria were intended to represent a reasonable estimate of pollutant concentrations consistent with the maintenance of designated water uses, states may appropriately modify these values to reflect location conditions.

The water quality criteria are generally represented in categories that are aligned with different surface water use designation. Concentrations are specified that, if not exceeded, should protect most aquatic life against acute toxicity or chronic toxicity (24-hour average). For many chemical compounds, specific criteria have not been established because of insufficient data.

Under the NJWPCA, the state has set applicable surface water standards based on classification. In February 1993, NJDEPE proposed reclassification of the Rockaway River from the Washington Forge Pond outlet to the Route 46 Bridge to FW2-TM(C1) (25 NJR 405). Should this reclassification be promulgated, discharge to the Rockaway River adjacent to the site would be required to meet the anti-degradation standard (not detectable at the Practical Quantitation Level) for all site constituents. Federal AWQCs are likely to be relevant and appropriate for compounds that do not have a New Jersey surface water standard.

Surface water criteria for those chemicals found at the Carpenter site are presented in Table 2-4. Federal and state MCLs for drinking water, shown previously in Table 2-1, may also be considered in establishing surface water discharge criteria.

2.2.3 Soil and Sediment Criteria

Resource Conservation and Recovery Act (RCRA) requirements may be applicable to the L.E. Carpenter site because contaminated materials found in the soil could be considered RCRA hazardous wastes (either listed or characteristic hazardous waste) if these soils have been actively managed. Acceptable levels of some organic and inorganic hazards constituents in solid waste have been established in 40 CFR 268.41 based on the amount of constituent released during the toxicity characteristic leaching procedure (TCLP). TCLP objectives for chemicals found in soil at L.E. Carpenter are presented in Table 2-5. Similarly, the RCRA Land Disposal Restrictions (land ban) may apply to actively managed (placed) soils with constituent concentrations in waste (CCW) of DEHP or xylene in excess of 28 mg/kg. Even though these contaminated materials may have been disposed of at the L.E. Carpenter site before the effective date of RCRA, RCRA regulations may be considered relevant and appropriate. RCRA LDRs also apply to materials which are removed for off-site disposal via land placement (i.e., landfill).

In the absence of promulgated cleanup standards for soils, New Jersey's draft Cleanup Criteria based on the NJDEPE February 3, 1992 proposed Cleanup Standards for Contaminated Sites, (N.J.A.C. 7:26D) are to be considered in establishing site specific cleanup goals. These draft standards are not promulgated and, therefore, subject to change before they become law. In developing these numerical standards, the primary basis used by NJDEPE is human health criteria. A one-in-one million additional lifetime cancer risk level was utilized as the definition of negligible incremental risk allowable. Additionally, potential routes of exposure were evaluated in determining the proposed cleanup standards. Residential surface soil standards were developed to be protective of toddlers present 24 hours a day. Nonresidential surface soil standards were developed as alternate cleanup standards that will accomplish the same degree of human health protection based on limited exposure pathways due to site conditions (i.e., continued industrial use of the site) or a remedial action which includes engineering controls of the contaminants. Subsurface soil cleanup standards were developed to be protective of groundwater quality in areas where groundwater is used as a potable drinking water source.

Table 2-6 lists the proposed cleanup standards for those parameters found in soil at the L.E. Carpenter site.

2.2.4 Air Criteria

National Ambient Air Quality Standards (NAAQS, 40 CFR 50) have been developed by EPA for seven classes of pollutants: particulates, sulfur oxides, nitrogen oxides, hydrocarbons, oxidants (ozone), carbon monoxide, and lead. The NAAQS focuses on two levels of control: primary and secondary. The primary standards apply exclusively to the protection of human health, while the secondary standards apply to the prevention of property damage. Table 2-7 provides a listing of NAAQS. It should be noted that these standards are not emissions (i.e., discharge) standards. They are standards to be met for the ambient air, after allowing for mixing of the particular discharge with ambient air. NAAQS attainment requirements are applicable only to major sources which are defined as emitting over 100 to 250 tons per year of regulated pollutants.

National Emission Standards for Hazardous Air Pollutants (NESHAP, 40 CFR 61) currently cover seven separate contaminants. They are beryllium, mercury, vinyl chloride, and radionuclides including radon, benzene, asbestos, and inorganic arsenic. Potentially, only beryllium, mercury, benzene, and arsenic may be of concern at the L.E. Carpenter site. However, the beryllium standard applies only to extraction plants, ceramic plants, foundries, incinerators and propellant plants which process beryllium ore, to machine shops which process beryllium, beryllium oxides or alloys of greater than five weight percent beryllium and to rocket motor test sites. The mercury standard only applies to mercury recovery from processing mercury ore, use of mercury chloro-alkali cells for chlorine production and incineration or dry wastewater treatment plant sludge. The NESHAP benzene standard application is limited to owners and operators of chemical manufacturing plants, coke byproduct recovery plants, and petroleum refineries. Likewise, the arsenic standard applies only to glass manufacturing plants, primary copper smelters, and arsenic trioxide and metallic arsenic production facilities. Based on the specificity of the processes delineated in the regulations, neither NAAQS nor NESHAP standards are applicable to the L.E. Carpenter site, but are to be considered.

New Jersey regulates the control and prohibition of volatile organic (NJAC 7:27-16) and toxic (NJAC 7:27-17) substance emissions. These subchapters set numerical maximum emission rates for storage and transfer of volatile substances and specify engineering controls for specific operations to minimize the impact of emissions of volatile and toxic compounds during specific operations (i.e., dry cleaning, surface coating, and graphic arts operations). In particular, NJAC 7:27-17 specifies the minimum height and emissions velocity of toxics being discharged through a stack. Specific provision within these standards are relevant and appropriate for the L.E. Carpenter site (i.e., engineering controls for storage tanks containing volatile organic compounds and maximum allowable hourly VOC emissions from source operations).

The Commonwealth of Puerto Rico Environmental Quality Board Regulation, Rule 404 is to be considered during any activity which may cause fugitive dust emissions. These operations include excavation, grading, and transportation of site soils or fill. Rule 404 specifies control methodologies (i.e., the use of water or suitable chemicals for dust control during demolition, construction and road grading, covering open bodied trucks transporting materials which are likely to give rise to dust, etc.) which may be used in the control of dusty activities. The rule also requires all fugitive dust be contained within the boundary of the property on which the emissions originate. As this Rule is not in force in New Jersey, it is neither applicable nor relevant and appropriate but rather to be considered at the request of NJDEPE.

2.2.5 Summary of Chemical-Specific Cleanup Standards

The NJDEPE and L.E. Carpenter have agreed to use the NJDEPE proposed Nonresidential Surface Soil Cleanup Standards to define areas of contamination and to direct remedial measures for soils. For groundwater, it was agreed that the NJDEPE proposed Ground Water Cleanup Standards for Class II-A Groundwaters will drive cleanup. Additional key ARARs that are likely to become of primary importance during remediation include:

- RCRA Land Disposal Restrictions (for actively managed wastes).
- The NJWPCA for surface water class FW-2 (trout maintenance).
- TCLP maximum concentrations (hazardous waste determination for land disposal).

Table 2-8 summarizes these chemical-specific ARARs for the media and contaminants of concern identified on Table 1-2. These criteria will serve as the basis of comparison for the detailed analysis of remedial alternatives in Section 6.

2.3 ACTION-SPECIFIC REQUIREMENTS

Location specific requirements "set restrictions on activities depending on the characteristics of a site or its immediate environs" (52 FR 32496). In determining the use of these location specific ARARs for selection of remedial actions at CERCLA sites, one must investigate the jurisdictional prerequisites of each of the regulations. Basic definitions, exemptions, etc., should be analyzed on a site specific basis to confirm the correct application of the requirements.

2.3.1 Federal and State Requirements

Regulations promulgated under the federal RCRA generally establish technology-based requirements for active or proposed hazardous waste facilities. NJDEPE is responsible for implementation of the RCRA program in New Jersey under the New Jersey Administrative Code, Title 7, Part 26 (NJAC 7:26). RCRA requirements include, for example, groundwater protection, general landfill standards, and standards for waste piles and surface impoundments. ARARs under RCRA include certain provisions of 40 CFR 264, such as those for closure and post closure (Subpart G, 40 CFR 264.110 et. seq.), surface impoundments (Subpart K, 40 CFR 263.220 et. seq.), waste piles (Subpart L, 40 CFR 263.250 et. seq.), land treatment (Subpart

M, 40 CFR 263.270 et. seq.), landfills (Subpart N, 40 CFR 263.300 et. seq.), incinerators (Subpart O, 40 CFR 263.340 et. seq.) and miscellaneous units (Subpart X, 40 CFR 263.600 et. seq.). Specific ARARs of concern in the Code of Federal Regulations, Title 40, Part 264 (40 CFR 264) depend on the remedy selected.

The New Jersey Technical Requirements for Site Remediation (N.J.A.C. 7:26E promulgated 7 June 1993) establish the requirements for remedial and post-remedial actions, a schedule for progress report items and permit application requirements to ensure early identification and approval of required permits. This new rule also specifies the requirements for the quality assurance/quality control activities to be implemented which will achieve the data quality objectives for a remedial activity.

Should hazardous wastes generated or originating on site be transported off site, regulations applicable to transporters of hazardous waste (40 CFR 263) would be applicable. RCRA part 263 standards specify manifesting procedures and transport and record keeping requirements. Transporters must obtain an EPA identification number and comply with the manifest system that documents shipment and delivery of hazardous waste. Hazardous wastes that may be generated through implementation of alternatives involving off-site treatment and disposal must go to a permitted RCRA facility. Any disposal activities for hazardous wastes at an off-site landfill will be subject to the requirements of the RCRA land disposal restrictions (1988). EPA directive 8347.3-05FS (July 1989) provides guidance on when land disposal restrictions are applicable to CERCLA remedial actions. Further, EPA Office of Solid Waste and Emergency Response (OSWER) Directive 9834.11 specifies the requirements that treatment facilities must comply with before they are determined to be acceptable for receipt of CERCLA wastes.

Treatment of contaminated media must ensure that levels of contaminants are below RCRA Land Disposal Restrictions (LDRs) Best Demonstrated Available Technology (BDAT) standards (40 CFR 268.43). These LDRs are applicable to the disposal of displaced soil, extracted floating product and groundwater. These standards are also applicable to treatment residuals, such as sludge produced during groundwater treatment.

The Corrective Action Management Units and Temporary Units; Corrective Action Provisions Under Subtitle C (40 CFR Parts 260, 264, 265, 268, 270 and 271) may regulate on-site management of remediation wastes. As defined by this rule, promulgated 16 February 1993, Corrective Action Management Units (CAMUs) are structured so that any waste managed within the CAMU which was generated as part of the corrective action at the facility would not be subject to RCRA regulatory disposal requirements. Therefore, remediation wastes may be placed within a CAMU without requiring pretreatment to RCRA LDRs.

If volatile organic substances are released to the atmosphere during remediation of contamination from the L.E. Carpenter site, such air emissions are regulated under NJAC 7:27-16. Other air emissions are also regulated throughout NJAC 7:27. An air permit may be required for certain remediation technologies under these regulations.

Proper disposal of residual wastes from any remedial option selected will depend on whether the waste is designated hazardous or nonhazardous. New Jersey Hazardous Waste Regulations (NJAC 7:26) define solid waste and hazardous waste and the criteria for listing hazardous waste. The regulations also stipulate that the generator must determine whether the waste is a hazardous waste (NJAC 7:26-8). RCRA Section 3001 (40 CFR 261) also defines and lists hazardous waste and characteristics of waste that are subject to RCRA controls. Section 3001(f) of RCRA contains provisions for the delisting of waste that would otherwise be considered hazardous.

Section 3004(c) of RCRA prohibits the disposal of bulk or noncontainerized liquid hazardous waste or free liquids contained in hazardous waste in any landfill. Disposal of nonhazardous waste liquid in any RCRA-permitted landfill is prohibited unless the only reasonable alternative available is disposal in a non-RCRA landfill or an unlined impoundment that contains hazardous waste, and placement in a RCRA landfill will not present a risk of contamination of any underground source of drinking water.

Final remediation in the vicinity of the L.E. Carpenter site may require the sealing of former residential wells in areas of contaminated groundwater. Although there are residential wells located within one mile downgradient of the site, they are not currently threatened by contaminated groundwater from the site and it is not known if the wells are used. The sealing of abandoned wells is regulated under NJAC 7:9-9. If the extraction of contaminated groundwater is selected as part of the site remediation, well installation regulated under NJAC 7:9-7 would be relevant. Extraction in excess of 100,000 gallons per day (69.4 gpm) would require a groundwater diversion permit.

For SARA remedial actions performed under the direction of NJDEPE, all applicable permits are required, and will be obtained. Obtaining approval for discharge will follow the informational and procedural requirements described in NJAC 7:14A.

Discharges to and contamination of groundwater in New Jersey are regulated with respect to groundwater monitoring requirements cleanup criteria, and record-keeping and reporting. Discharges to surface water are subject to effluent standards and minimum treatment requirements (NJAC 7:9-4.1 et seq.). Discharges to groundwater are subject to requirements described in NJAC 7:14A-6. The State of New Jersey is authorized by EPA to administer wastewater discharge permits under the NJPDES. General information and filing requirements for NJPDES permits are described in NJAC 7:14A. Specifically, information regarding Treatment Works Approval (TWA), which is required prior to treatment and discharge of groundwater, may be found in N.J.A.C. 7:14A-12.1 et seq.

Discharges to publicly owned treatment works (POTWs) require the endorsement of the local sewerage authority, the Rockaway Valley Regional Sewerage Authority (RVRSA). RVRSA has adopted a policy of not approving the discharges from groundwater remediations. This policy effectively limits discharge options at the site to the drainage ditch, the Rockaway River, or reinfiltration to groundwater.

2.3.2 Additional Guidelines To Be Considered

In addition to the previously described potential action-specific ARARs that appear as regulations, other action-specific guidelines that are not regulations should be considered. These guidelines are primarily based on policy set during the implementation of previous remedial actions or on research performed.

Guidelines on the discharge of effluent to a publicly-owned treatment works can be found in New Jersey's "Guidelines - Waste Discharge". Additional information on the discharge to surface water that may pertain to remediation at the L.E. Carpenter site can be found in:

- Required information for discharges to surface waters (DSW) from Superfund sites (memo from Edward H. Post, 1 November 1983).
- Report: Toxic Management - Regulating Point Source Discharge of Toxic Substances into New Jersey Waters.
- Indirect discharge permitting procedures.

Additional guidelines and policies on air emissions that may apply to certain remedial technologies at the site include:

- Required pretest protocol information.
- Protocol - continuous emission monitors - DEQ.
- Guidelines for review of applications for toxic substances emissions.
- Information required to determine if equipment used in hazardous waste site cleanups complies with New Jersey Air Pollution Control Regulations - memo from William O'Sullivan, 23 March 1987.
- Technical Guidance Study - "Development of Example Procedures for Evaluating the Air Impacts of Soil Excavation Associated with Superfund Remedial Actions" EPA 450/4-90-014.
- "Guidance on Applying the Data Quality Objectives Process for Ambient Air Monitoring Around Superfund Sites" Stages I and II EPA 450/4-89-015, Stage III EPA 450/4-90-005.

Guidance on the management of excavated soils may be found in an attachment to the technical guidance document entitled "Interim Closure Requirements for Underground Storage Tank Systems - NJDEPE Division of Water Resources, Bureau of Underground Storage Tanks", dated September 1990.

If groundwater remedial action requires off-site discharge of treated water (either to surface water or a POTW), the Discharge Monitoring Report (DMR) Instruction Manual for Discharge to Surface Water (DSW) and Significant Indirect User (SIU) Permits (NJDEPE, May 1991) should be consulted. This document delineates the New Jersey Pollutant Discharge Elimination System (NJPDES) Program Objectives, provides definitions used in the regulations and discusses the requirements for completing DMRs. If groundwater remedial action requires recharge of treated water to the subsurface, OSWER Directive 9234.1-D06 (Applicability of LDRs to RCRA and CERCLA Groundwater Treatment Reinjection) should be considered.

If incineration is a selected remedial strategy, the Hazardous Waste Incineration Guidance Series Handbooks should be consulted.

- Volume I: Permit Writer's Guide to Test Burn Data, EPA/625/6-86/012.
- Volume II: Guidance on Setting Permit Conditions and Reporting Trial Burn Results, EPA/625/6-89/019.
- Volume III: Hazardous Waste Incineration Measurement Guidance Manual, EPA/625/6-89/021.

Guidance on design and construction soil cover/cap systems may be found in the EPA Seminar Publication titled "Requirements for Hazardous Waste Landfill Design, Construction, and Closure." Further guidance may be obtained from the EPA RCRA Guidance Document: Landfill Design, Liner Systems, and Final Cover (PB87-157657).

Office of Solid Waste and Emergency Response (OSWER) Directive 9320.2-3A (dated April 1989) may be consulted for guidance in the correct procedures for completion and deletion of NPL sites from the National Priorities List.

2.4 LOCATION-SPECIFIC REQUIREMENTS

Location-specific regulations promulgated by RCRA would be applicable to the siting of on-site treatment alternatives. Part of the L.E. Carpenter site is located in a 100- and 500-year flood plain as delineated in the Final Supplemental Remedial Investigation (WESTON 1992). A treatment facility in this part of the site must be designed, constructed, operated, and maintained to avoid washout (40 CFR 18). In a normal flood plain or lowlands near surface water bodies, action must be taken to avoid adverse effects, minimize potential harm, and restore the site to its natural state (Executive Order 11988). The Fish and Wildlife Coordination Act (16 USC 661 et seq.) provides that any alternative adversely affecting a stream or river shall also include action to protect fish and wildlife.

An additional state requirement to be considered is the New Jersey threatened plant species list. Habitats of endangered plant/animal species are contained in this list.

NJAC 7:7E-3 lists special areas such as flood plains, wetlands, and endangered or threatened wildlife or vegetation species habitat that involve special policy considerations. Rules governing flood hazard areas are contained in NJAC 7:13 Flood Hazard Area Regulations. Flood Hazard Area Regulations were promulgated in accordance with the Flood Hazard Control Act (N.J.S.A. 58:16 - et. seq.), which regulates land use in designated floodway, designates minimum standards to govern development and use of land in flood fringe areas, and sets requirements to minimize damage to structures and the affected stream through the use of stream encroachment permits. The New Jersey NJAC 7:2-11 describes the location, designation, classification, and management of natural areas in the state. The Wetlands Act of 1970 (NJSA 13:9A-1 et seq.) and the Freshwater Wetlands Protection Act define wetlands and list regulated activities and permit requirements for wetlands in New Jersey. Regulated activities include dredging and any construction or alteration. A wetlands assessment was performed at the L.E. Carpenter site to determine the presence of and delineate aerial extent of wetlands at the site, and to evaluate the potential impacts of remedial action alternatives on wetlands. The assessment report may be found as Appendix C in the Final Supplemental Remedial Investigation report (WESTON, 1992). The evaluation of impacts determined that excavation in non-wetland areas could cause siltation and sediment loading in the Rockaway River and negatively impact downstream wetland areas, thereby requiring extensive wetland mitigation as specified in N.J.A.C. 7:7A-14.

The National Historic Preservation Act (16 USC 470 et. seq.) is applicable to those properties included in, or eligible for, the National Register of Historic Places. This ARAR requires that action be taken to preserve historic properties. Planning of action to minimize the harm to national historic landmarks is required. The Stage 1A Cultural Resource Survey identified that Building 2, located on North Main Street across from the majority of the L.E. Carpenter site, has considerable potential to constitute a significant archeological resource. A Stage II evaluation was recommended if remedial actions undertaken at the site affect Building 2 (JMA). Furthermore, the Stage IA survey indicated the L.E. Carpenter property possesses a moderate potential to contain archeological resources at soil depths below those previously disturbed (fill) areas. Therefore, a Stage IB survey was recommended if remediation activities disturb soils at depths below that which has previously been disturbed (due to historic filling of mine spoils).

The Federal Water Pollution Control Act (FWPCA) requires a permit from the Corps of Engineers and consideration by both the EPA and the Fish and Wildlife Service before dredge and fill activities. These actions are required before any dredging. In addition, the FWPCA specifies what will be done with the dredged material.

The Farmland Protection Policy Act (7 USC 4201 et. seq.) was promulgated "to minimize the extent to which Federal programs contribute to the unnecessary and irreversible conversion of farmland to non-agricultural uses ...". While three irrigation wells were located within one mile of the L.E. Carpenter site, one of these wells is associated with a nursery, which is no longer operational. The remaining two are utilized for lawn maintenance (sprinklers). The land use in the immediate vicinity of the site is industrial/residential. The Farmland Protection Policy Act is therefore neither applicable nor relevant and appropriate for L.E. Carpenter.

2.5 SUMMARY OF ACTION AND LOCATION-SPECIFIC ARARs

Because the preferred remedial action and locations at which the remediation is required have not yet been identified, none of the action-specific and location-specific ARARs can be considered "applicable" at this time. Table 2-9 presents a summary of ARARs and materials "to be considered" for the L.E. Carpenter site. Whether each of the ARARs is determined to be applicable or relevant and appropriate depends on which remedial measures are implemented.

WESTON

SECTION 3.0

GENERAL RESPONSE ACTIONS

A number of general response actions have been identified for the L.E. Carpenter site based on previous studies and the ongoing RI. To determine general response actions for the site, the conceptual site model, incorporating potential contaminant sources, transport pathways, and receptors, was evaluated. Six types of response actions were identified:

- No Action.
- Institutional Controls.
- Containment.
- Removal/Collection.
- Treatment.
- Disposal/Discharge.

The no action response is used as a stand-alone option and as a baseline against which other measures are evaluated. This alternative must be considered throughout the FS process. No action allows current conditions and processes at a site to continue. Institutional controls reduce exposure to media affected by the site by restricting future access or providing alternative resources. Containment actions limit the spatial distribution of the contamination, control migration, and minimize the potential for direct contact with contaminants without altering the chemistry of the contaminants. Removal or collection actions alter the position or presence of the contaminated media without altering the chemistry of the contaminants. Treatment actions alter the chemistry of the contaminants to render them less toxic, less mobile, or of reduced volume. Disposal/discharge actions address the ultimate location of the contaminant or medium.

Potential remedial technologies are evaluated in Section 4 by environmental medium. Present concerns and possible general response actions for each medium of concern are presented in the following subsections.

3.1 SOIL

As described in Subsection 1.6, the predominant soil contaminant at the L.E. Carpenter site is DEHP. PCBs, lead, and antimony were found to a lesser extent. Soils with a DEHP, xylene or ethylbenzene concentrations in excess of the proposed New Jersey subsurface cleanup standards extend over an area of approximately 14,500 yd^2 on the eastern portion of the site, and are also located in an area associated with former underground storage tanks. Additional isolated soils may be encountered during the remedial action which exceed these cleanup criteria. Any action taken to remediate soils will be based on contaminant concentration rather than geographic location. However for the purpose of this report, estimates of soil volumes potentially requiring remediation were calculated based on interpretation of analytical results and best professional judgement of an areal extent of soils exceeding proposed action levels. Based on a estimated contaminant depth of 1 ft below the lowest observed water table elevation, the volume of soil in this area is estimated to be approximately 31,500 yd^3.

The highest concentrations of the organic contaminants are present in the immiscible product zone, 3 to 5 ft below ground surface. Concentrations in surface soils (less than 1 ft deep) were significantly lower than in the deeper soils. Xylene and ethylbenzene were not present in any of the surface soil samples in excess of the proposed NJDEPE nonresidential cleanup standard. Only two of the 14 surficial samples from the eastern portion of the site, HA-2 and TP-83A, contained DEHP in excess of the standard. For the 12 test pits in this eastern site area where both shallow and deep samples were collected, the average ratio of DEHP in the deep sample to the shallow sample was over 8:1. These facts support the conclusion that the immiscible product layer is the primary source of contamination in this area, and that most of the soil contamination is present in the deeper soils.

Remedial measures that would be effective in phthalate removal and/or treatment will dictate the general response action for soil. Because DEHP adsorbs strongly to soil, its extraction from the soil matrix would occur at a slow rate.

The volume of soil to be remediated is relatively large, and any major excavation operation would be impeded by buildings, driveways, and activity on the site. Soil remediation measures would prove disruptive to the operations of current tenants in several buildings on site. Efficient use of space for the excavation, staging of soil, equipment, and decontamination areas would be imperative. The relatively high water table at the site would decrease excavation efficiency. Since the site is active and will continue to be used as an industrial site in the future, excavated areas will need to be backfilled with the treated soil or new fill material. Backfill of clean material would be done in such a manner that it is not recontaminated by the floating layer. If the soil is transported off site for disposal, the latter option would be employed. In situ response actions (such as bioremediation) have also been evaluated.

Some of the soils on the Wharton Enterprises Property contain both DEHP and PCBs. Some of the isolated lead/antimony hot spots may also contain DEHP. Therefore, more than one remediation technology may be required on these soils. It appears for the most part that the PCBs, lead, and antimony are in the surface soil, while the DEHP (except in TP-83A) does not exceed the cleanup standard in the surface soil. However, land ban restrictions (LDR) will impact any proposed removal action for soils containing DEHP, since levels exceeding the LDR limit for DEHP (28 mg/kg) may be present in the isolated hot spot soil.

An area believed to be a former subsurface disposal area was discovered during the recent upgrade of the immiscible product recovery system. Fill, which appeared to be a combination of a white chalky substance and dried sludge, along with the remains of several 55-gallon drums were located. This fill material appears to have been deposited in a solid layer approximately 0.5 foot thick at a depth ranging from 3 to 5 feet below ground surface. The volume of this material is estimated to be approximately 160 cubic yards. Analyses of samples collected in this area indicate high concentrations (9,300 to 31,000 ppm) of ethylbenzene and xylenes, as well as metals (i.e., lead and antimony) at concentrations exceeding proposed cleanup standards. (However, the soils surrounding this material were not sampled.) These analytical results support the assumption that this material is a potential source area for groundwater contamination, and indicate this material should be looked upon as a discrete area during remediation.

3.2 GROUNDWATER

Groundwater general response actions for the site will have to address both the immiscible product and dissolved constituents in groundwater. The contamination is centered in the shallow (rather than intermediate or deep) groundwater zone. While the presence of the immiscible product does not necessarily preclude general response action addressing soils or dissolved constituents in groundwater, the concentration of contaminants in the immiscible product is several orders of magnitude greater than in the other media and would greatly limit the effectiveness of soil or groundwater remedial action. Contaminants can be removed more effectively as immiscible product than as a dissolved phase in groundwater. For this reason, it is clearly advisable to complete the removal of the immiscible product during the early phases of the site remediation.

Recovery of the immiscible product by skimming is more effective than extraction of product and groundwater with subsequent separation. Water table depression, which involves extracting groundwater from several feet below the immiscible product layer, would significantly improve collection rates of the existing skimming wells at some point in the future when the collection from these wells drops off.

The primary dissolved groundwater contaminants are DEHP, xylene, and ethylbenzene. The volume of the contaminated shallow groundwater zone, defined as the saturated zone to a depth of 32 ft below ground level (the average top screen elevation for intermediate zone wells), is conservatively estimated at 1.7×10^8 gallons. This volume estimate is based on the groundwater with DEHP concentrations in excess of the NJDEPE proposed Class IIA Groundwater Cleanup Standard of 30 ug/L, which covers the area between the river and the drainage ditch from the vicinity of MW-1 to beyond MW-14s.

Since the water solubility of DEHP is low (300 ug/L at 20°C), it appears that DEHP is present as a suspension of immiscible product, is adsorbed to suspended particles, or is being solubilized by other solvents (such as xylene and ethylbenzene) in the groundwater to levels exceeding its aqueous solubility. In areas where the groundwater contains significant concentrations of both VOCs and phthalates, more than one treatment technology may be required, although technologies effective on all groundwater contaminants are preferred.

Considering the relatively high permeability of most of the soil, groundwater recovery should be effective. The groundwater may be collected by active methods such as extraction wells or by passive means such as an interceptor trench, and treated aboveground. As with any groundwater collection system, contaminant collection efficiency will decrease over time as concentrations decrease. Pending regulatory approval and technical viability, treated water may be infiltrated or allowed to infiltrate into groundwater at the site, may be discharged to the surface water, or a combination of both. In situ treatment schemes for groundwater (such as in situ biodegradation) have also been evaluated.

SECTION 4.0

IDENTIFICATION AND SCREENING OF TECHNOLOGIES

4.1 SCREENING PROCESS

In this section, remedial technologies and technology process options will be identified that satisfy the preliminary remedial action objectives outlined in Section 1. Process options and remedial technology types may be eliminated from further consideration during this step if they are not feasible for the L.E. Carpenter site. Table 4-1 summarizes the preliminary identification of remedial technologies and process options for each of the environmental media being considered for the site.

In this step, the number of potentially applicable technology types and process options is reduced by evaluating the options with respect to technical implementability. The term "technology types" refers to general categories of technologies. The term "technology process options" refers to specific processes within each technology type. Several broad technology types may be identified for each general response action, and numerous technology process options may exist within each technology type.

Remedial technologies and process options were considered according to their technical feasibility with regard to site and waste characteristics and applicability to the potential problem areas of the site. Process options with no applicability to the wastes at the site were not considered. Potential remedial technologies and process options were identified and screened using the following process:

- The technology is described along with a discussion of its potential application to potential site problem areas.

- Each technology or process option is evaluated based on effectiveness, implementability, and cost. These criteria are applied to the technologies and the general response actions they are intended to satisfy and not the site as a whole. The evaluation focuses on effectiveness at this stage, with less emphasis on implementability and cost evaluation.

- A recommendation is then made to retain or eliminate the technology from further consideration based on the criteria described above.

As described in Section 3, the technologies considered will be classified under six types of general response actions:

(1) No Action.
(2) Institutional Controls.

(3) Containment.
(4) Removal/Collection.
(5) Treatment.
(6) Disposal/Discharge.

4.2 REMEDIAL TECHNOLOGIES FOR SOILS

4.2.1 No Action Option

Under the No Action option, no future remedial measures would be implemented. Some degradation of organics in the soil and groundwater may occur over time, but the rate and extent are difficult to predict, and are expected to be minimal. Soil contamination remaining on site could potentially leach contaminants to the groundwater. Organic compounds have been observed to have impacted groundwater quality. However, leaching of metals has been very limited (see Subsection 1.6).

Recommendation: The No Action option will be considered further as required under the National Contingency Plan.

4.2.2 Institutional Controls

This option involves annotating the deed for all or part of the site to allow commercial use only unless or until NJDEPE approves of residential use. In addition, deeds for this property could be annotated to provide notice that groundwater usage, excavation of soil, or other usage is restricted or prohibited. The deed would also apprise prospective buyers of the groundwater quality at the site. Furthermore, the deed could be annotated to prohibit the installation and/or limit the use of on-site wells for purposes of groundwater monitoring and recovery only. Thereby, future issuance of well permits for this property could be restricted. The cost of implementation of this option could be low or moderate, depending on legal expenses.

This option would also involve maintenance of currently emplaced site fencing. The L.E. Carpenter site is currently enclosed in two separate fenced zones. The southeastern portion is enclosed by a fence that extends the length of the eastern side of the railroad right-of-way (RR-ROW) along the bank of the Rockaway River, and follows the property line until it intersects the RR-ROW. The tenant occupied portion of the site is also fenced. That fence extends the length of the western side of the RR-ROW, along Ross Street, North Main Street, and the Rockaway River to the RR-ROW. Warning signs are posted along the fence enclosing the eastern portion of the site. Maintenance of the integrity of the fence would reduce the possibility of direct contact with site soils by trespassers and the local residents.

Recommendation: Limiting certain uses in, and potential exposure to, contaminated or potentially contaminated areas would be effective in controlling exposure and reducing risks. Therefore, this option will be considered further.

4.2.3 Containment Technologies

4.2.3.1 Surface Runoff Controls

Surface runoff controls include site grading, surface water diversions (berms and drainage ditches), revegetation, silt fences, and sedimentation basins. In general, these measures divert surface water run-on, control surface runoff, and minimize potential erosion and sediment transport. Regrading and the construction of drainage ditches reduces infiltration of water into the subsurface, which minimizes contaminant transport to groundwater.

Surface runoff controls also reduce transport of contaminants via erosion. Geotextile silt fencing and revegetation provide additional measures for controlling erosion of contaminated soils.

Sedimentation basins are used to settle suspended solids entrained in stormwater runoff as well as to provide temporary storage capacity for subsequent water treatment or analysis. A sedimentation basin would be required to meet NJDEPE requirements for improvements, including a double liner. A sedimentation basin would potentially be subject to contamination from the shallow floating product layer and would place space constraints on other remedial actions and future uses of the site.

Recommendation: Site grading, surface water diversions, revegetation, and silt fences will be retained for further consideration. Some form of these surface runoff controls are likely to be a component of any remedial alternative involving any of the soil remediation technologies discussed below. Sedimentation basins will no longer be considered based on the difficulty of implementation at the site, unless they are constructed at a shallow depth.

4.2.3.2 Capping/Covering

Capping consists of covering an area with low-permeability materials. As a result, the infiltration of precipitation and surface water is reduced, and the leaching of soil contaminants is minimized. Run-on and runoff are directed to the edges of the cap. Capping is also highly effective for the prevention of human and ecological exposure to surface contaminants via direct contact, dust inhalation, or erosion. Covering provides a physical barrier between areas of concern and potentially affected receptors.

A variety of materials can be employed in the construction of a cap, including clay, geotextiles, and construction materials such as concrete or asphalt. Typical caps use a combination of cap materials and a drainage layer to provide maximum net impermeability. Single-layer caps/covers are acceptable when leaching of contaminants and infiltration is not significant but direct contact with soils is a concern. In addition to the low-permeability layer itself, caps often include higher permeability surface covering with vegetation to control erosion. Soil covers may be designed without a low permeability layer if the main purpose of the cover is to preclude contact with and erosion of surficial soils. The cap or cover design would incorporate regrading of the affected area, as necessary, to facilitate surface drainage.

Capping is a well established technology for controlling infiltration of surface water, thereby reducing potential mobility of residual contamination due to percolation of rain water. Complete implementation would include site security, vegetation control, and cap maintenance programs, as well as provisions for managing water runoff. A properly designed, constructed, and maintained cap/soil cover can have a long useful life with relatively low maintenance costs. Caps/covers would be less effective at controlling migration of organic soil contaminants that are located within the range of groundwater table fluctuation.

Since 42% of the total surface area at the site is already paved, construction of an asphalt or soil cap/cover over localized areas of soil contamination would be readily implementable.

Recommendation: Capping would be an effective option for controlling the migration of and contact with surficial soil contamination and will be considered further.

4.2.4 Removal Technologies

4.2.4.1 Excavation

Excavation would involve the physical removal of contaminated soil. This process could be used in conjunction with a soil washing or other ex situ remedial alternative whereby the cleaned soil would be returned to the excavation(s) or a soil removal alternative whereby the excavated soils would be evaluated for waste characterization and disposed of at a properly permitted facility. The excavation(s) would be filled with certified clean fill material from an off-site source.

Excavation and removal alternatives may be particularly advantageous in the removal of localized sources of soil and groundwater contamination. Once this is accomplished, further site remediation would be accomplished via groundwater treatment. Moreover, excavation techniques are relatively simple and are well established.

However, there are several significant disadvantages to large scale excavation-related remedial alternatives when compared to in situ remedial treatments. The main disadvantage is that these alternatives would require the transfer and handling of large volumes of contaminated materials. This, by its nature involves a significant risk of the transfer of contaminants to previously uncontaminated materials and/or media. For example, the excavation activities could result in the transfer of contaminants from the soil to the air via the emission of volatiles and particulates. Compliance with the NAAQs of the Clean Air Act would require the control of these emissions, and this could prove to be difficult or infeasible. The surface transfer of these contaminated soils, either to a temporary staging area prior to on-site treatment or to a permitted off-site facility, would require significant containment and decontamination efforts to minimize the risk of the inadvertent spread of contamination to uncontaminated areas.

There are also site-specific considerations which must be included in the evaluation of excavation-related remedial alternatives. The presence of boulders in the soil column will make excavation difficult. Due to the poor stability of the soil, contingency measures such as shoring and slope stabilization would be required. The large excavated area potentially under consideration would require careful grading to insure that surface runoff meets the state water quality standards. The presence of groundwater monitoring and remediation facilities would further complicate these activities. Excavation of contaminated soils around the existing monitoring and recovery wells and the associated surface and subsurface piping would be difficult and could result in permanent damage to this equipment.

Recommendation: Excavation will be retained for further consideration, especially with respect to the remediation of areas of localized surficial soil contamination. Certain significant problems which are intrinsic to excavation-related remedial alternatives would make large scale soils excavation difficult at this site.

4.2.5 Physical Treatment Technologies

4.2.5.1 Soil Washing

As is the case with all of physical, chemical, and thermal treatment technologies to be discussed, soil washing would involve the excavation and staging of contaminated materials as an initial step. This technology refers to methods for removing contaminants and/or the fine soil particles to which they are adsorbed by contacting soil particles with reagents that consist of a water/surfactant or water/solvent solution. The waste chemicals are solubilized and retained in the fluid phase. The scrubbing action can disintegrate soil aggregates, freeing contaminated fines from the coarser sands and gravels. In addition, the abrasive scouring action removes surficial contamination from larger particles. Soil washing is usually performed using a multistaged batch process. The conceptually similar process when performed in situ is termed soil flushing. This technology is discussed later in Subsection 4.2.9.2.

The soil washing process is adaptable to either organics or inorganics through the use of various washwater additives. Reagents that may be used for metals removal include dilute acids and complexing agents such as EDTA or citrate buffer. Because of the variety of contaminants present at the site and the strong attachment of some compounds, particularly phthalates, to soil, multiple extraction steps and washwater additives could be necessary. In many cases, the washwater may be treated, recovered, and recycled.

A disadvantage to soil washing is that the elutriate stream would require treatment and disposal. Because of the potentially large volume of soil subject to treatment, the volume of elutriate to be treated could be significant.

Soil washing, in addition to solubilizing contaminants, also reduces the volume of soil requiring subsequent treatment or disposal. In most cases of soil contamination, the major portion of contaminants adsorb to the soil fines, silts, and clays with a particle size of less than 2 mm. Most of the contaminants are sorbed to the fines fraction because of their higher surface to mass ratio and higher natural organic carbon content, which acts as an organophilic adsorption media.

In the first step of a typical soils washing treatment train, oversized particles (larger than 2 inches) are removed prior to treatment. The coarse fraction is then abraded. The fines slurry, consisting of the wash solution, the solubilized contaminants, and the contaminated fines fraction of the soil, may be either treated or dewatered and disposed of off site. Treatment technologies that have been successfully applied to the fines are bioslurry reactors and pozzolanic stabilization. The coarse soils are typically suitable for backfilling without further treatment. The used washing fluid would be likely to require further treatment.

Extensive treatability testing would be required to determine a workable soil washing process design since relatively few field tests of this process have been conducted.

Recommendation: Soil washing will be retained for remedial alternative development.

4.2.5.2 Stabilization

Stabilization is a treatment process used to immobilize hazardous waste constituents in a solid matrix through mixing with additives and binders. The process involves excavation of the contaminated soils or sediments and conversion of these materials to a solid mass that would immobilize leachable contaminants. Stabilized materials are typically sent to a permitted landfill for disposal. Stabilization of soils can also be applied without excavation by adding stabilizing agents via a deep soil mixing auger, although effectiveness may vary. Stabilization may also be applied to soils treated for their organic content as a "polishing" step to reduce the mobility of metals to within TCLP criteria prior to final disposition. A process such as stabilization may be necessary for isolated hot spot soils if the soils leach heavy metals during the TCLP analyses at concentrations exceeding their respective TCLP limits.

Various stabilization techniques are available to stabilize contaminated liquids and solids, as described below:

- Cement-based processes -- Wet wastes and sludges are combined with Portland cement and proprietary additives. The mixture solidifies, developing low-permeability and high structural strength in 7 to 28 days, and can be disposed of in a landfill.

- Lime-based or pozzolanic processes -- A fine-grained aluminous, siliceous material is mixed with lime, water, and the waste constituents. A solidified mass forms in 7 to 28 days that has low permeability and moderate structural strength.

- Thermoplastic processes -- A molten thermoplastic material, such as asphalt, paraffin, bitumen, or polyethylene, is blended with dried wastes at temperatures ranging from 130 to 230°C. When the material cools, it solidifies. The solid is usually coated with the thermoplastic or containerized.

- Thermosetting organic polymer -- A monomer is mixed with a catalyst and the waste. A polymer is formed that entraps the waste in a solid matrix.

Solidification/stabilization has been used successfully to immobilize waste constituents, particularly inorganics. However, certain binding materials are sensitive to wastes containing organic compounds and other proprietary binding agents are specifically formulated to stabilize materials containing organic contaminants. Laboratory bench-scale or pilot-scale tests would be required to confirm that the soil contaminants are adequately immobilized and to determine the optimal binding material for the site. Existing research suggests that stabilization may be inappropriate for organic contaminated materials. An application for which stabilization has been widely used is the immobilization of metals in sludges, soils, and incinerator ash. Stabilization can be performed in situ or ex situ depending on site logistics and characteristics of the material. In addition, this technology may be sensitive to variations in waste composition such as those found at the L.E. Carpenter site. Bench-scale testing is also recommended for application of stabilization technology to wastestreams without organic constituents.

Stabilization reduces the mobility of contaminants but does not destroy them. Therefore, the risk of exposure resulting from leaching contaminants at low rates over the long term still exists.

Recommendation: Due to concerns about its effectiveness, stabilization will not be retained for further consideration as an independent process option. However, since it has been widely effective in immobilizing inorganic constituents in previous cases, it will be retained for use as a finishing step in conjunction with other technologies, such as treatment, flushing, bioremediation, or incineration, which remove or destroy the organic constituents in the waste matrix. It will also be retained for use on metals contaminated soil hot spots if the soils fail the TCLP analyses.

4.2.5.3 Supercritical Fluid Extraction

This process, which is applicable to both soil and groundwater, uses fluids in a supercritical state, such as liquid carbon dioxide (CO_2), propane, or butane, as a solvent to remove organics. Propane or butane would generally be used with sludges, and CO_2 with water. The fluids experience altered solvent properties that allow the dissolution and/or volatilization or organic contaminants, which can make extraction more rapid and efficient than conventional soil washing methods. Another potential advantage of supercritical over conventional soil washing is the ease of separating the solvent from the dissolved organic contaminants for reuse.

Bench-scale testing has shown this to be an effective technology for phthalate removal. However, this technology is still in the developmental phase and sufficient information is not available to assess the applicability for this site. The process energy requirements and operating costs would be relatively high.

Recommendation: Since supercritical fluid extraction is still in the developmental stages, it will not be retained for further consideration relative to other physical treatment technologies.

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4.2.6 Chemical Treatment Technologies

4.2.6.1 Wet Air Oxidation

Wet air oxidation refers to a high-temperature, high-pressure oxidation of dissolved or finely divided organic and inorganic constituents in an aqueous medium. High pressure increases the solubility of oxygen in water, which helps drive the oxidation reaction. The oxidation reactions are exothermic, which makes the process thermally self-sustaining as long as the organic content of the process stream is sufficiently high.

After the wastes are oxidized, the pressure is reduced and the effluent is discharged to a separator where liquid and gaseous streams are separated. Both of these streams may require additional treatment before discharge.

The EPA's Risk Reduction Engineering Laboratory database cites a 99.99% DEHP removal efficiency for wet air oxidation applied to sludges with total organics concentrations in the 1,000 mg/L range. However, the concentration of organics in the groundwater present at the L.E. Carpenter site may be too dilute to sustain the oxidation reaction. This technology is being considered as a potential treatment for soil because it would be more applicable to the organics concentration range found in soils near the water table at the site. Wet air oxidation is potentially applicable to soil in a slurry form, although it has been tested and applied primarily to sludges and concentrated wastewater. Size classification for soils would be required to remove oversized and large size fractions. Wet air oxidation is not appropriate to unmoistened soil or to floating product because it requires an aqueous environment. Treatability testing would be required to determine the effectiveness of this technology to soil slurries and to the contaminants of concern at the site.

Generally, wet air oxidation is not justified for small quantities due to the relatively high capital investment. Materials of construction are stainless steel or more costly alloys.

Recommendation: Wet air oxidation will be retained for further consideration as a treatment for soil in a slurry form although little testing has been conducted as to wet air oxidation's applicability to slurries. Wet air oxidation will not be retained for consideration as a treatment for groundwater since the concentration of organics may be too dilute to be applicable.

4.2.6.2 Supercritical Water Oxidation

Supercritical water oxidation, like wet air oxidation, is a technology originally developed as a treatment for sludges and high-concentration organic wastewater, which may, based on its effective concentration range, apply to treatment of soil slurries at this site. As with WAO, a minimum strength organic stream, reportedly as low as 20,000 ppm, is required to make the oxidation reaction self-sustaining.

The distinction between supercritical water oxidation and WAO is that this technology relies on the improved solubility of oxygen and organics in water in its supercritical state rather than high pressure as a means of driving the oxidation reaction.

Treatability testing would be required to determine the effectiveness of this technology to soil slurries and to the organic contaminants of concern at this site.

Recommendation: Supercritical water oxidation will be retained for further consideration as a treatment technology for soils, although its applicability to soil slurries is uncertain. This technology will not be retained for consideration for groundwater treatment since the contaminants in the groundwater below the L.E. Carpenter site are too dilute for this process option.

4.2.7 Thermal Treatment Technologies

Thermal treatment technologies rely upon relatively high temperatures to either destroy organic contaminants or separate them from natural materials. While the classical approach involves off-site incineration of wastes, alternative on-site procedures using similar procedures are in various stages of development.

4.2.7.1 Incineration

With treatment by incineration, materials contaminated with organics are destroyed by controlled combustion under net oxidizing conditions. The products of incineration generally include CO_2, water vapor, sulfur dioxide (SO_2), nitrogen oxides (NO_x), hydrochloric acid (HCl) gases, and ash. Incineration can be used to destroy organic contaminants in soils, sediments, sludges, recovered floating product, or gaseous emissions from other treatment processes.

Potentially applicable equipment include rotary kiln, fluidized bed, and infrared incinerators. Rotary kiln incinerators utilize a rotary kiln as the primary furnace configuration for combustion. Fluidized bed incinerators are refractory-lined vessels containing a bed of inert granular material (i.e., silica sand) that is heated and agitated by combustion air. The waste materials are burned when they contact the hot bed material. This type of incineration is particularly suited to treatment of contaminated soil or sediment because the abrasive action of the bed material acts to scrub the soil free of attached organics in addition to incinerating the material. Infrared incinerators subject waste materials to intense infrared radiation, which causes combustion of waste with a minimum of particulate-producing turbulence. Electric pyrolyzers thermally degrade organics to carbon monoxide, hydrogen, and carbon using a thermal plasma generated by an electric arc in dry, low-pressure air.

Incinerators are capable of accepting all matrices of organic wastes. However, oversize pieces of material have to be reduced to below 2 inches in diameter before being fed into the fluidized bed, infrared, and electric pyrolyzer systems. Also, wastes containing metals constituents may require emissions control and stabilization of metals in the residual ash stream.

Incineration is a desirable process because the organic contaminants are permanently destroyed. However, the local environment needs to be protected from the criteria pollutants in the gaseous emissions, which can be accomplished with conventional pollution control devices. There are high costs associated with incineration of soils and sediments due to the low Btu content (heating value) of the materials. It may be possible to increase the heating value of the soil and the overall feasibility of incineration at the site by the addition of the recovered floating product layer.

Recommendation: Incineration will be retained as a process option for remedial alternative development. However, based on an historical lack of public acceptance of on-site incineration in New Jersey, this process option may present difficulties in implementation. All four types of incinerators/pyrolyzers would be effective in destroying the organics present in soils at the site. All except electric pyrolysis are commercially available as transportable systems for on-site treatment. Rotary kiln will be evaluated as being representative of the incineration remedial technology for on-site use. Because the logistics, transportation risks, and costs of off-site incineration are considerable, incineration on site may be more viable for bulk soils, off-site incineration would likely be more appropriate for small volumes of treatment residuals or isolated hot spot soils (i.e., disposal area sludge/fill).

4.2.7.2 Low-Temperature Thermal Treatment

The low-temperature thermal treatment process has become well established as a proven option for removing volatile organic compounds, such as solvents or fuel oil, from soil or sediment. The heart of this treatment system is the thermal processor, an indirect heat exchanger that is used to heat and consequently dry the contaminated materials. Oil is used as an indirect heat transfer fluid to heat the thermal processor to 400 to 1,500°F. The hot oil is recycled to obtain maximum thermal efficiency. The net effect of heating soils or sediments is to volatilize the organics with low boiling points. Once volatilized, the organics are destroyed in an afterburner or recovered as condensate.

The soil is conveyed from the feed end of the thermal processor to the discharge end by twin screws. Both the screws and the screw conveyor trough are heated internally by the circulating hot oil. The continuous movement of the screws convey and thoroughly mix the contaminated soils. This intermixing action causes breakup of soil lumps and allows soil particles to come into frequent contact with the hot surfaces.

The afterburner, if used, provides a residence time of greater than two seconds at a minimum temperature of 1,800°F to ensure complete destruction of the volatilized organics. The VOC-contaminated air serves as the combustion air for the burner flame. Therefore, the volatile organics are exposed to the high temperatures and turbulence within the flame vortex, which ensures complete thermal destruction of the organics. A low temperature condenser can be used to condense the organics for shipment offsite, as an alternative. Processed soil may be returned to the site if it meets the prescribed criteria.

Low-temperature thermal treatment has been successfully applied to a number of semivolatile compounds. However, it is not likely to be applicable to DEHP, whose boiling point is 727°F. As is the case with incineration, this technology does not destroy inorganic contaminants. A significant advantage of low-temperature treatment relative to incineration is that for soils with high concentrations of heavy metals, the metals are not transformed into more volatile species such as metal chlorides or sulfides. As a result, gaseous emissions (i.e., stack gas concentrations) of heavy metal compounds are much lower for low-temperature treatment.

The costs of this technology are moderate relative to other types of treatment. Although more cost-effective than incineration, low-temperature thermal treatment can be rather energy-intensive for small waste volumes.

Recommendation: Because of its inability to treat the main contaminant of concern (DEHP) at the L.E. Carpenter site, low-temperature thermal treatment is not retained for further consideration.

4.2.8 Biological Treatment Technologies

4.2.8.1 Solid Phase Treatment/Composting

Solid phase treatment methods are directed toward enhancing biochemical mechanisms to detoxify or decompose the contaminants in the soil or sediment. This is accomplished by excavating the soils of concern and spreading them over a large area at a shallow depth (12 to 18 inches maximum). Nutrients are added and oxygen is introduced by using agricultural-type equipment (i.e., tillers and plows) and irrigating the soil or sediments. Native or specialized microorganisms can be used. Historically, this treatment process was conducted on the ground surface and was referred to as land farming. Treatment of hazardous materials typically require that the process be conducted over an impervious liner to prevent constituent migration.

Composting is a thermophilic (high temperature) process. The mechanism for composting is similar to solid phase biotreatment; however, composting is accomplished by mixing a percentage of the waste with a biodegradable and structurally firm material such as chopped hay, livestock feed, rice hulls, or woodchips. The supplemental carbon sources foster the development of a rich microbial population. Metabolic heat from the degradation of the organics heats the compost pile. Composting is applicable in cases where biodegradation is too slow or is incomplete at lower temperatures.

To date, the primary application of solid phase biotreatment and composting techniques has been the treatment of hydrocarbon refinery wastes and petroleum hydrocarbon contaminated soil. It is, however, being used at some CERCLA sites for treatment of contaminants such as creosote. Laboratory and pilot-scale tests would be required to confirm the feasibility of this process and to determine the optimum solid phase/composting technique for the problem areas of the site. Laboratory treatability testing has been performed on site soil and groundwater samples and has demonstrated that DEHP and other organics of concern at the site are biodegradable.

Solid phase biotreatment or composting is not physically feasible for the L.E. Carpenter site because the required surface area to spread the soil over would be many times the total site area. Other potential drawbacks with this technology are the potential release of volatiles from the soil during excavation and aeration and the need to contain the migration of contaminants from the treatment area.

Recommendation: Large scale solid phase biotreatment/composting are not viable technologies for the L.E. Carpenter site due to spatial limitations and will not be considered further. It will be retained as a candidate technology for possible application to smaller quantity or hot spot soils.

4.2.8.2 Slurry Bioremediation

Slurry bioremediation, also called bio-slurry treatment, refers to the biodegradation of excavated soils or sediments in a mixed reactor. This treatment option is feasible in situations where solid phase techniques are not applicable due to space constraints or the need for better control of operating parameters (e.g., improved oxygen contact or temperature optimization) exists.

Bioreactors can provide aeration, mixing, temperature control, and volatile emissions control for the treatment of a soil slurry (typically 30 to 50% solids by weight). Oversized coarse material is removed prior to treatment using a trammel screw and/or a screw classifier. Preconditioning is required to slurry the soil. Use of groundwater from the site may be feasible to form the soil slurry. Hydraulic residence time in the reactor varies depending on the nature of the contaminants, their concentration, and cleanup goals. Several bioreactors can be arranged in series to provide a system for continuous feed and overflow to achieve optimum biokinetic rates. Upon discharge from the reactors, the decontaminated slurry is dewatered. The water can be recycled and the solids meeting cleanup goals can be backfilled.

Soil slurry bioreactors as large as 300,000 gallons (1,485 cubic yards) are currently available. Smaller bench or pilot scale units are available for treatability studies, which would be required to assess the optimal operating parameters and required residence time specific to the site soils.

Recommendation: Enhanced bioremediation will be retained for further consideration.

4.2.9 <u>In Situ Treatment Technologies</u>

In situ treatment technologies are inherently attractive because wastes are treated in place, thereby minimizing the potential exposure risks involved in the handling and transport of wastes and avoiding the expense of excavation. However, potential disadvantages with in situ treatment include the potential difficulty of establishing hydraulic control over the subsurface zone, and difficulties in verifying the levels of treatment realized.

The physical logistics and the dewatering required for excavation of soils in the water table at the L.E. Carpenter site would prove to be difficult. Therefore, technologies that exhibit the potential for treatment of soils without excavation warrant consideration.

4.2.9.1 In Situ Biodegradation

In situ biodegradation, also referred to as bioreclamation, is a technique for treating contaminated soils and groundwater in place by microbial degradation. Addition of oxygen and nutrients to the groundwater enhances the natural biodegradation of organic compounds by microorganisms, resulting in the breakdown and detoxification of the organic contaminants. These microorganisms can either be naturally occurring or specifically adapted. Typically, oxygen (sometimes in the form of hydrogen peroxide) and nutrients (sometimes accompanied by surfactants) are delivered via groundwater recirculated through a system of extraction and infiltration points throughout the treatment zone.

To date, in situ biodegradation has been applied primarily to sites contaminated with readily biodegradable, nonhalogenated organics, mainly gasoline and other fuel products. In situ biodegradation has also been successfully applied to xylene and ethylbenzene. A site specific treatability study indicates that DEHP is amenable to microbial degradation.

The principal factors which must be considered in evaluating in situ biodegradation include:

- Whether the contaminants of concern are inherently biodegradable, and under what conditions and

- Whether sufficient control over the subsurface environment can be achieved to ensure that all contaminated zones are treated.

- Whether sufficient control over the subsurface environment can be achieved to assure no off-site migration.

The inherent biodegradability of site contaminants (including DEHP) has been demonstrated in a site specific treatability study performed on groundwater and soils collected from the L.E. Carpenter site. These data suggest that bioremediation of DEHP is possible under certain conditions. At the same time, the sorption of DEHP to soils may hinder the process, and desorption of DEHP from soils may be the rate limiting step in the process.

With respect to the second key factor above, the critical issue is the control of flow through the treatment zone to provide treatment to every contaminated area while providing complete containment of both mobilized contaminants and added reagents. Providing sufficient oxygen and nutrients to all parts of the treatment zone is critical to the biological process. Based upon available data, the permeability of the soils at the site would appear to be conducive to bioreclamation, although their heterogeneity and large number of boulders could hinder adequate distribution of oxygen and nutrients.

In addition, treatment of contaminants in the vadose zone or the immiscible product layer zone would be more complicated because an aqueous environment is required. Biodegradation occurs at the contaminant/moisture and the soil/moisture interfaces, and necessary water and dissolved oxygen would be excluded in the immiscible product layer. At the L.E. Carpenter site, it may be necessary to first remove the majority of the immiscible product so that in situ biodegradation can achieve its full potential. In addition, the nutrient/oxygen delivery system must be designed to maximize the contact between vadose zone soils and the infiltrated water, which would increase the efficacy of vadose zone contaminant biodegradation.

Following evaluation of site environmental factors and waste characteristics, systems for introduction of nutrients and oxygen into the groundwater would be developed. For in situ biodegradation, infiltration wells, well points, trenches, drain fields, or infiltration galleries would be installed using conventional construction techniques.

Bioreclamation is sensitive to changes in temperature, pH, redox potential, and the concentration of oxygen, water, and nutrients. These parameters would need to be monitored and controlled during operation. In addition, the long-term effects of nutrient introduction on groundwater must be evaluated. In particular, nitrogen applied as a nutrient may be oxidized to nitrate and needs to be contained.

Final contaminant reduction is difficult to predict but may be estimated based on the results of site-specific treatability studies. Furthermore, biological processes may enhance contaminant mobility. Preliminary treatability studies indicate that DEHP at the L.E. Carpenter site is amenable to biological treatment, and that mobilization of DEHP from site soils is the limiting factor for this process.

Recommendation: In situ biodegradation is retained for further consideration.

4.2.9.2 Soil Flushing

Similar to soil washing, this technology refers to methods of mobilizing and extracting contaminants from soils in situ. Soil flushing is accomplished by use of aqueous or aqueous/chemical solutions (i.e., water/surfactants or water/solvents) that are applied to the area of contamination and then extracted for removal, recirculation, or on-site treatment and reinfiltration. This is usually accomplished by constructing infiltration galleries, injection wells, or other delivery methods and utilizing groundwater extraction wells or interception trenches for recovery. In some situations, the soil flushing system can be designed to function as an in situ bioreclamation system after flushing has removed the majority of contaminants from the subsurface soils. Multiple extraction steps may be required.

The control of flow through the subsurface zone to ensure that all contaminated materials are adequately contacted and that flushing solutions do not migrate outside the collection zone is critical to the success of this technology. These steps may be more difficult to implement in situ since variability in soil characteristics would affect the quality of contact with the extractant.

Therefore, the correct placement of recovery wells to provide complete capture of the flushing agent and to prevent the increased transport of mobilized contaminants to the groundwater outside the collection zone is important. By using an appropriately designed groundwater extraction/recharge system, flow control is possible. However, in highly heterogeneous materials, adequate control and distribution of flow may be difficult to achieve.

A treatability study on soil cores collected from the L.E. Carpenter site indicates that VOCs are readily flushed from the soils under bench scale conditions utilizing potable water as the flushing solution. The study further indicated that a surfactant may be used to enhance the removal of DEHP from soils. A determination was made during the treatability study that the geotechnical characteristics of site soils (e.g., permeability) are favorable to an in situ treatment process such as soil flushing.

Recommendation: Based on the results of the site specific treatability study, soil flushing will be retained for further consideration.

4.2.9.3 In Situ Volatilization

In situ volatilization (ISV), also referred to as soil venting, removes volatile organics by mechanically drawing air through soil pore spaces. An ISV system consists of an array of vents (vacuum wells) in the unsaturated zone of a contaminated soil area. These vents are manifolded to vacuum pumps that provide the negative pressure to draw air through the soil. The organics volatilize as the air moves through the soil. The VOC-laden air is then collected and treated through carbon adsorption or other means prior to venting to the atmosphere.

ISV is well suited to the porous soils present at the L.E. Carpenter site. However, a limitation of the ISV process is that contaminants must be volatile enough to transfer from the soil to the gas phase. ISV is not effective on inorganics and most semivolatile compounds. Furthermore, because water blocks air movement, ISV can only be applied in the unsaturated soil zone. Vendor information indicates that the process is not applicable to soils near the surface unless a cap exists.

Recommendation: ISV is a potentially effective remedial technology for remediation of xylene and ethylbenzene contaminants in soils above the water table; however, it would be ineffective on the semivolatile compounds (i.e., DEHP), the primary contaminant of concern unless it is applied as bioventing. ISV will be retained for further consideration for remediation of areas of the site soils where volatile contaminants exceed cleanup levels and semivolatile contaminants do not.

4.2.9.4 Electromagnetic Heating

Electromagnetic heating, also referred to as in situ radio frequency treatment (IRF), involves the application of electromagnetic energy in the radio frequency range (2 to 45 megahertz) to heat soil and volatilize the organic contaminants. The process is similar to the heating accomplished with a microwave oven, although the frequencies are much lower. Up to 5,000 tons of soil can be heated at one time by means of an array of exciter and ground electrodes inserted in boreholes throughout the contaminated zone. Rapid heating of the soil surrounded by the electrodes is accomplished because the heating is not dependent on the relatively slow process of thermal conduction. The process is typically operated at a temperature of 200°F, although in some cases temperatures as high as 725°F can be achieved. The transfer of organics into the vapor phase is enhanced by the steam stripping effect caused by the vaporization of soil moisture.

To collect the volatilized contaminants, a vapor contaminant cover is placed over the treatment zone. To accelerate the collection, a vacuum is normally applied to the hollow electrodes in the vapor containment zone similar to the process previously described for ISV. The collected vapors are condensed and collected for disposal. Noncondensables are treated using carbon adsorption prior to venting to the atmosphere. IRF has the benefit of treating a wider range of organic compounds than ISV. Like ISV, IRF does not require water injection or large treatment systems and would adapt well to the porous soils at the site. However, both technologies are limited to the removal of organics in the unsaturated zone because vapor transport is blocked by the presence of a liquid phase. IRF would not be as effective in removing DEHP because its boiling point, 727°F, is too high. IRF would be an effective technology only for compounds with boiling points below approximately 500°F.

Recommendation: Because it may have limited effectiveness on DEHP and it has not been demonstrated in the field, electromagnetic heating will not be retained for further consideration.

4.2.9.5 In Situ Vitrification

Vitrification is a process where in-place soils are converted to a durable, glass-like material as they are heated to extreme temperatures. This conversion is achieved by passing an electrical current through the subject soils, which in turn produces temperatures in excess of 3,100°F. The in situ vitrification process is as much a stabilization process as it is a destruction process.

The basic design of an in situ vitrification system consists of four electrodes driven into a soil area up to 400 ft^2. The maximum achievable melt depth varies inversely with increasing electrode spacing. When an electric current is passed through these electrodes, the temperature of the affected soil increases until the soil vitrifies. In the process, most of the organic constituents in the soil are pyrolyzed in the melt or migrate to the surface, where they combust in the presence of oxygen. The off-gases are collected in a hood and directed to an off-gas cleaning train. Inorganic compounds in the soil are effectively bound in the solidified glass. The bulk leach rate of the vitrified mass is reported to be significantly less than granite, marble, or bottle glass.

Soils with permeabilities in the range of 10^{-4} to 10^{-9} cm/sec are considered suitable for vitrification, even in the presence of groundwater or below the water table. Soils with permeabilities higher than 10^{-4}, as is the case with this site, are difficult to vitrify in the water table unless additional steps are taken, such as drawing down the local water table. Treatability testing must be performed to determine the performance of the technology on site soils. Since some volume reduction through consolidation is to be expected, clean fill is applied as a cover material.

Cost for this technology is expected to be high because of the extremely high power requirements needed to glassify soil.

Recommendation: It is recommended that in situ vitrification be given no further consideration because the soils at the site do not exhibit suitable permeability and uniformity.

4.2.10 <u>Disposal Options</u>

4.2.10.1 On-Site RCRA Landfill

Waste materials such as incinerator ash, treatment sludge, spent carbon, or excavated soils from other areas and sediments could be disposed of by placement in an on-site landfill. Depending on the classification of the material to be disposed, the landfill would have to meet RCRA requirements for hazardous or solid waste. The landfill would require compliance with RCRA and NJDEPE standards for both double-liner and cover systems. In addition, post-closure care, maintenance, and leachate management would be required. The contaminated materials would be partially or completely excavated and placed in the on-site landfill. This option does not require transportation of waste material off-site and may provide secure containment on-site, but it does not reduce the toxicity or volume of the waste materials.

Siting this facility would be difficult due to limited open area from which to choose. A landfill could not be developed in the flood plain area of the site. Residential and other setback requirements further reduce the available space on site. The shallow water table would further complicate the implementation of an on-site landfill, since the construction of an aboveground vault would be necessary to increase the buffer zone between the base of the landfill and the water table. Disposal of wastes in a landfill, either on site or off site, would be subject to land ban restrictions on the waste's toxicity and leachability if the action constitutes waste placement.

The cost of an on-site landfill, which includes excavation, construction, and continuing leachate treatment and monitoring, is relatively high.

Recommendation: Based on spatial, logistical, and regulatory limitations (such as the requirement that the bottom surface of the lower landfill liner be a minimum of five feet above seasonally high groundwater table), the construction of an on-site landfill will not be considered further for action constituting placement of hazardous waste.

4.2.10.2 Off-Site Landfill

Off-site disposal involves the collection and staging of contaminated materials and the transportation of the materials to an approved disposal site that meets applicable RCRA requirements and regulations. Depending on their characterization, the wastes may be sent to a RCRA Subtitle C (hazardous wastes) or Subtitle D (solid waste) facility.

Commercial disposal facilities must meet stringent analytical, state permitting, and compliance standards. Using off-site facilities requires meeting U.S. Department of Transportation (DOT) requirements for hazardous waste transport. Commercial RCRA landfill capacity is limited; therefore, the type and quantities of waste must be approved by the facility before disposal. The off-site facilities may be reluctant to accept large quantities of waste. In addition, certain hazardous wastes may require dewatering, stabilization, or treatment prior to landfilling in order to meet land ban restrictions.

Recommendation: Since a variety of treatment alternatives may result in the production of treatment residuals (i.e., wastewater treatment sludge, discarded personal protective equipment), disposal at an off-site RCRA landfill will be retained for further consideration.

4.3 REMEDIAL TECHNOLOGIES FOR GROUNDWATER

4.3.1 No (Additional) Action Option

Under the No (Additional) Action plan for groundwater, the existing program of quarterly monitoring and collection of the immiscible product layer using the EIPRS skimmer pumps for product recovery would continue. Although the original sources of the groundwater contamination are believed to have been removed, the contamination would persist. Downgradient well users are not currently impacted, but future impacts cannot be ruled out based on available information. Impact of the groundwater contamination on the ecosystem downstream of the drainage ditch in the Rockaway River, if any, would continue, but would dissipate over time.

Recommendation: The No (Additional) Action option will be further considered as required under the National Contingency Plan.

4.3.2 Institutional Controls

The residential well survey has established that there is no negative impact on downgradient receptors at this time. Private water supply response actions are considered as contingency measures that could be put in place if future testing indicates conditions which warrant such a response action.

4.3.2.1 Alternative Water Supplies

This option involves providing an alternate water supply to nearby residents who use domestic wells in areas that might be impacted by groundwater contaminants. It could be accomplished by providing the hookup of homes to the municipal water distribution system or by providing bottled water to serve residents in the area of influence.

This technology will be effective in preventing use of contaminated water by nearby residents, although no reduction in the concentrations of constituents is achieved by means other than natural attenuation. The hookup of homes to the municipal water distribution system would probably be the most acceptable and cost-effective method of providing an alternative water supply since the system already serves almost every home in the region. Provision of bottled water would be effective as an interim step until hookup of affected homes to the municipal water system could be affected.

Recommendation: Although there is presently no evidence to suggest that downgradient groundwater users are impacted by L.E. Carpenter activities, if downgradient receptors were in the future impacted by groundwater contamination from the site, provision of an alternative water supply for uses of groundwater as potable water by hookup to the existing water distribution system may be appropriate and will be considered further. Provision of bottled water will be considered further as a temporary remedy pending any required hookup of homes to municipal water supply.

4.3.2.2 Groundwater Treatment at Points-of-Use

In point-of-use treatment, carbon filters or other home treatment units would be made available to affected groundwater users, if any, to remove contaminants at the point-of-use. Carbon filters are effective for the removal of many dissolved and suspended organic compounds.

The advantage of this option is that only the water used is treated. Difficulties of implementation include ensuring that all points-of-use are accounted for and that the units are maintained and replaced when necessary. This approach should be combined with filing a well restriction area so that new water supply wells are not installed in the affected area. If installed, these new wells would have to be monitored and treated as necessary. Costs would be relatively low because the number of potentially impacted wells is low.

Recommendation: Since the number of private downgradient wells that may be affected is small, groundwater treatment at points-of-use will be considered further as a contingency measure.

4.3.2.3 Deed Restriction

A deed restriction, in the form of a Declaration of Environmental Restrictions and Grant of Easement, would provide a legally binding means of restricting property use, access, and disturbance of any long term implemented remedial strategy. Further, development of a well restriction area, in conjunction with a deed annotation, would serve three additional purposes: to provide notice of the existence of contaminants in groundwater; to prohibit or restrict the construction of any or all types of wells in the restricted area, and to preserve the integrity of the selected groundwater remedial action by controlling the placement of any or all types of wells. Use of these restriction would provide protection to the potentially affected local populace from exposure to areas of contaminated groundwater. These restrictions would remain in place unless or until the groundwater quality was returned to contaminant concentrations which would allow for unrestricted use.

Recommendation: Deed restrictions specific to groundwater usage, including development of a well restriction area, will be considered further.

4.3.3 Containment Technologies

The objectives of containment measures are to redirect the flow of groundwater around an area and/or contain groundwater and contaminants within a specific region. These technologies both reduce the likelihood of contaminant migration and increase the residence time of the contained groundwater volume in a specific location, which can be useful in focusing the effect of in situ treatment technologies. Hydraulic containment using extraction wells is described in Subsection 4.3.4. Physical groundwater containment technologies (hereafter referred to as containment technologies) include:

- Slurry walls
- Grout curtains
- Sheet piling
- Electro-osmosis

These technologies are primarily effective for containment of groundwater in the overburden, although some containment structures have been installed in deeper zones. The first three technologies are passive subsurface barriers that are generally connected to an existing low-permeability layer to ensure that constituents of interest do not migrate under the barrier. However, hanging barriers (i.e., not keyed into a low-permeability layer) can be used to contain the migration of floating product.

4.3.3.1 Slurry Walls

Slurry walls are the most common subsurface barrier. They are relatively simple to construct in most soil types and are very effective in reducing lateral groundwater flow in unconsolidated materials possessing a high permeability. Installation of a slurry wall involves constructing a trench under a slurry that is usually comprised of a mixture of bentonite and water. Once the trench is constructed, an engineered soil mixture is combined with the slurry to backfill the trench and form the wall.

Slurry wall construction requires moderate capital costs and has low operation and maintenance costs. The construction cost depends on the required length and depth of the trench. At the L.E. Carpenter site, one potential location for a slurry wall would be along the eastern (downgradient) boundary of the site near the drainage ditch. Slurry walls can also be used as a groundwater barrier in combination with extraction or injection wells to control the well's zone of influence. Normally, slurry walls are keyed into bedrock or a low-permeability clay layer. At the L.E. Carpenter site, a slurry wall would be limited to the control of floating product and the uppermost portion of the groundwater zone, since the bedrock is too deep to tie into to form a complete groundwater barrier. However, a slurry wall installed along the Rockaway River, for example, would reduce the volume of clean water collected by the extraction wells during remediation, thus reducing the volume of water being treated and maintaining higher contaminant levels in the extracted water, which improves treatment efficiency.

Recommendation: Slurry walls will be considered further to contain the potential migration of floating product or control groundwater flow from the Rockaway River and/or around extraction or infiltration wells.

4.3.3.2 Grout Curtains

Like slurry walls, grout curtains form a subsurface barrier constructed primarily in unconsolidated material. They are constructed by pressure injecting grouting material through a pipe at various intervals to form a wall. For grouting to be effective, the subsurface must have moderate to high permeabilities so that the grout may spread out during pumping and fill the voids. Applications of grout injection often experience significant problems in forming a continuous wall due to unequal permeabilities and distribution of the grout. Given the variable permeability of the fill and the large number of boulders in the near-surface soils at the L.E. Carpenter site, grout injection may not provide a sufficient barrier to groundwater flow in unconsolidated material.

Recommendation: Due to concerns about its effectiveness, particularly in varying soil types such as those found at the L.E. Carpenter site, grout curtains will not be considered further.

4.3.3.3 Sheet Piling

Sheet piling involves driving steel or high-density polyethylene (HDPE) sheets into the ground to form a subsurface wall to contain lateral groundwater movement. Sheets are interlocked before insertion and are driven a few feet at a time for the entire length of the wall until the entire wall is driven to the desired depth. HDPE sheet pile sections can be "locked" together using watertight joints during installation.

The geologic cross-section presented in WESTON (1992) indicate that the surficial deposits over much of the site contain abundant cobbles and boulders. Cobble and boulder size materials are common in the glacial outwash deposits in the region. These materials are particularly abundant in the areas of the site where sheet piling would be used for containment purposes. For example, the surficial deposits in the vicinity of the Air Products drainage ditch feature up to five (5) feet of quaternary alluvial silt which contain frequent boulders supported by the finer grained matrix. These deposits overlie channel gravel deposits consisting of Rockaway River Outwash and described as grey/brown, coarse to fine gravel, little coarse to fine sand, abundant cobbles and boulders. Large boulders (up to two feet in diameter) have been observed at the surface, particularly in the southern areas of the L.E. Carpenter property and on the Wharton Enterprises property. Due to the large quantity of boulders and cobbles in the surficial deposits at the site, sheet piling could not be feasibly installed.

Recommendation: Sheet piling will not be considered further because of the difficulty of installation in the soils present at the site.

4.3.3.4 Electro-Osmosis

Electro-osmosis is the phenomenon of migration of a liquid through a porous, charged medium under the action of an applied electric field. The positive ions that predominate in the layer of water next to the soil particles migrate toward the negatively-charged electrode (cathode). Due to viscous drag, the water in the pores is drawn by the ions and therefore also flows toward the cathode. Electro-osmosis has been used to divert the flow of groundwater, and dewater soil, mine tailings, and waste sludges. It may be possible to divert groundwater flow by placing electrode pairs upgradient of the site. With the anodes facing the upgradient flow, the groundwater could be diverted around the site.

This technology is unproven as it might be applied at the L.E. Carpenter site. Since the electric field must be continuously maintained, operating costs would be high. It is unclear how a floating product would respond to the induced electric field. Field testing would be required to assess its performance on a large scale.

Recommendation: Electro-osmosis is relatively unproven and its effectiveness at the L.E. Carpenter site would be limited. Therefore, this option will not be considered further.

4.3.4 Collection Technologies

Groundwater collection process options include extraction wells and interceptor trenches. Because of the immiscible product floating at the surface of the water table, technologies specific to the collection of this separate phase are also applicable. As a rule, collection technologies are used in conjunction with treatment and disposal options.

4.3.4.1 Immiscible Product Recovery

Remediation of the immiscible product layer at the site has been ongoing since May 1984. In September 1989, the original electromechanical product recovery system was replaced with a specific gravity-type skimmer system to improve the operational reliability and accelerate the recovery of immiscible product. Previously, product recovery was operational at wells MW-6, MW-7, and MW-10. The thickness of immiscible product at MW-7 has been reduced to a thickness at which it is no longer recoverable (less than 0.1 inch).

The passive recovery (i.e., no water table depression) system was upgraded in 1991. The upgrade included the installation of three recovery wells, and installation of skimming equipment in monitoring wells MW-6, MW-10 and MW-11s, and in recovery wells RW-1, RW-2, and RW-3. The recovery system in RW-1 operates independently from the system in all other wells, which are manifolded together.

The existing product recovery system is a "SOS Shallow Well-Specific Gravity Skimmer" designed and marketed by Clean Environment Engineers. The primary components of the system include the in-well skimmer assemblies, the air-logic controllers, the air-operated discharge product pumps, the air compressors, and the product recovery tanks. The immiscible product intake is attached to the skimming head, which, because of its specific gravity, sinks in the immiscible product and floats on water. The pump is timed so that any product above the skimming head is withdrawn at regular intervals that can be adjusted to the rate at which the immiscible product is released from the soil.

The upgraded recovery system, which included the installation of three 8-inch recovery wells, has been operational since November 1991. Using the enhanced system, the recovery rate of immiscible product has been increased to approximately 400 gallons per month.

After groundwater remedial measures have been initiated, the product recovery system can be converted into an active recovery system with groundwater depression. However, water table depression may expose additional soils located within the saturated zone to potential contamination via contact with the floating product. Therefore, the potential effects of water table depression will be considered during Remedial Design. This potential negative impact of water table depression is mitigated by the fact that initial drawdown calculations indicate that the maximum drawdown is expected to be approximately 2 ft, which is less than the observed range of normal water table fluctuation at the site. As the recovery of floating product progresses, the placement of additional wells to optimize remediation would be considered.

Recommendation: Continued passive immiscible product recovery has been included as a part of all comprehensive site alternatives under consideration, including the No Action option. Active immiscible product recovery will be further considered in conjunction with groundwater remedial strategies.

4.3.4.2 Extraction Wells

Groundwater extraction is used to prevent migration of mobile constituents of concern by controlling the groundwater flow system. This is accomplished by the construction of a series of recovery wells that are screened in the affected water-bearing zones. Pumps are typically installed in each well to pump the water to the surface. The groundwater can then be treated and discharged to surface water, groundwater, or a POTW.

The extraction well layout can be designed for groundwater/floating product recovery or for groundwater interception. Recovery wells are typically placed near source areas to retrieve the affected groundwater. At sites where floating product recovery is in operation, extraction wells perform the additional function of accelerating the collection of the immiscible product phase by depressing the water table near the skimming system although deeper soils may be exposed and contaminated by the product during drawdown. However, drawdown is expected to be less than the observed water table fluctuation at the site. The cone of depression created by extraction of groundwater far below the surface of the water table causes the floating product to flow downgradient to the skimmer. For permeable soils such as those present at the L.E. Carpenter site, the cone of depression would be wide and shallow, thereby minimizing water table drawdown and lessening the potential for contaminating deeper soils. An optimal arrangement would be to conduct both floating product recovery and groundwater extraction from different depths in the same well. The groundwater drawdown may be operated either periodically or continuously. At sites such as the L.E. Carpenter site where the natural groundwater flow gradient is not steep, the gradients induced by a recovery well may prevent off-site migration of groundwater and serve as an effective form of containment as well as collection. Well installation at the L.E. Carpenter site is made more difficult by the large number of boulders present in the overburden.

The two phases, floating product and the primary groundwater, should be extracted separately to maximize treatment efficiency and to prevent possible emulsification of the two phases, which increases the difficulty of phase separation and treatment.

Utilization of extraction wells for collection of groundwater from overburden formations is a proven technology for mobile, relatively soluble compounds such as xylene and ethylbenzene. This technology is most effective in higher permeability, homogeneous materials. During groundwater extraction, the concentrations of mobile compounds may be substantially reduced in a moderate period of time, but low levels usually persist. At that point, large volumes of water must be treated to remove low concentrations of constituents of interest. Depending on the residual concentrations of constituents within the aquifer and the action levels for those constituents, active control measures could continue for an extended period. When the cleanup goals are met and remedial action ceases, continued desorption of contaminants from the soils into the groundwater, determined by the solubility limits of those contaminants, could raise residual contaminant concentrations in the groundwater to levels greater than cleanup goals. Pulsed pumping, in which extraction and injection wells are cycled through active and resting phases, can be employed to enhance removal of constituents. The resting phase can allow sufficient time for constituents to diffuse from low-permeability zones, or from dead end pores and fractures into adjacent high-permeability zones, allowing higher constituent concentrations to be achieved in and extracted from the high-permeability zones.

The low water-solubility and mobility of DEHP makes it difficult to recover from the subsurface. The addition of surfactants or co-solvents to the reinfiltration or reinfiltrated water could enhance the solubility and facilitate the recovery of hydrophobic constituents such as DEHP. Treatability testing performed on site samples indicates that the use of a surfactant (Brij

30/35) is effective in desorbing DEHP from the soil phase and mobilizing it in the water phase. However, enhanced recovery of DEHP utilizing surfactants or co-solvents other than those contained in the floating product has not been attempted on a full-scale basis, and precautions need to be implemented to ensure the mobilized constituents are collected and do not migrate further downgradient. Proper design of a groundwater pumping scheme can capture and contain the contaminant plume.

Extraction wells can also be designed for groundwater interception. The distinction between interception and recovery wells lies primarily in their intent; interception wells are designed to maximize groundwater containment. Interception wells are placed downgradient near the leading edge of the groundwater containing the constituents of interest. Interception wells are placed so that their cones of depression overlap. As a result, the interceptor wells form a hydraulic barrier to lateral groundwater flow.

Recommendation: Recovery wells and interceptor wells will be retained for further consideration. However, since contaminants have been detected on Wharton Enterprises property, the cooperation of the owners of affected off-site areas on which recovery and/or interceptor wells are located would be required for implementation of this process option.

4.3.4.3 Interceptor Trenches

Interceptor trenches, or subsurface drains, are used to prevent migration of contaminants by passively or actively (through pumping) collecting the groundwater for removal and/or treatment. The interceptor trench process option uses common engineering and construction practices. Trenches or subsurface-graded french drains are used to intercept and collect groundwater and floating product. The technical basis for this collection method is that groundwater will follow a path of least resistance. Therefore, collection trenches use highly permeable materials in the water-bearing zone to convey groundwater flow to a collection sump. An interception trench leading to a collection sump being actively pumped can serve as an effective means of water table depression, which accelerates the collection of floating product.

The collection sump could include an oil/water separator that serves both to remove/recover free phase material and as a pretreatment step for subsequent unit processes for which even small quantities of free organics can impair performance (e.g., activated carbon). An oil/water separator that allows sufficient holding time and quiescent conditions for the phases to separate would likely be a preliminary step in any remedial alternative involving water treatment.

Interceptor trenches would be limited to the collection of floating product and near-surface groundwater. A trench depth greater than approximately 8 ft would be difficult to construct and involve extensive shoring due to the soil conditions present at the site. These conditions include the angle of repose for the non-cohesive fill material coupled with the proximity to the Rockaway River. However, a central collection sump could be constructed to depths greater than eight feet. An interceptor trench system has an inherent disadvantage in that it is both difficult and expensive to modify as required to optimize removal efficiency as the remedial action progresses.

Recommendation: Interceptor (or collection) trenches will be retained for further consideration due to their ability to collect floating product and shallow groundwater from low permeability media.

4.3.5 Physical Treatment Technologies

The physical treatment options to be screened include activated carbon adsorption, air stripping, steam stripping, membrane separation, resin adsorption, and liquid phase separation.

4.3.5.1 Activated Carbon Adsorption

The activated carbon adsorption process is one of the most frequently applied technologies for the removal of trace organic compounds from an aqueous solution. In this process, organic compounds are adsorbed onto granular or powdered activated carbon as the aqueous stream contacts the carbon. Adsorption is a surface phenomenon whereby physical and chemical forces act upon soluble organic molecules within the pore spaces of the carbon. There are two main factors that influence adsorption (of organic compounds) by activated carbon, namely:

- Solubility - Adsorption increases with decreasing solubility of the organic compound.

- Affinity - The greater the specific attraction of the solute molecule to the carbon surface, the more easily it is adsorbed.

Typically, a packed bed activated carbon adsorption system consists of a pressure vessel that contains the carbon. The groundwater can flow through the vessel in either an downward or a upward mode. Also, it may flow through a number of beds in series or parallel. Gravity and pressure flow units with multicolumns in series are the most commonly designed contacting systems. Untreated water enters at the column inlet and treated water leaves at the outlet. Adsorption of organic compounds will occur until such time as there are no more active sites available in the column. The column is exhausted when breakthrough of the constituent(s) of concern occurs. Breakthrough is defined as when the target concentrations of organic compound(s) in the effluent are exceeded.

Activated carbon units can be skid-mounted and placed on flat-bed trucks or railcars for transport to various sites. Additional equipment that may be required include pumps and piping, backwash equipment, and carbon transfer equipment.

Spent carbon containing the concentrated organic constituents of interest must be replaced and disposed or regenerated. Granular carbon can be regenerated in a furnace by incinerating the organic matter and thus removing it from the carbon surface. Approximately 5 to 10% of the carbon is also destroyed in this process and must be replaced with new or "virgin" carbon.

Granular carbon is also often regenerated using steam to desorb the organic compounds. The capacity of regenerated carbon is slightly reduced from that of "virgin" carbon. Spent carbon, if not regenerated, will require proper disposal.

Carbon adsorption has been frequently used for the treatment of aqueous waste streams and has been demonstrated as very effective for removal of phthalates, xylene, and ethylbenzene. However, there are limitations to the carbon adsorption process that restrict treatment of aqueous wastestreams to those in which the suspended solids concentrations are less than 50 parts per million (ppm) and the organic compound concentrations are less than 10,000 ppm (1%). Pretreatment methods, such as settling, filtration, coalescence and oil/water separation, can be used to remove suspended solids, emulsified oil, and free-phase organics.

As previously noted, carbon adsorption is often used in conjunction with other groundwater control technologies such as aerobic or anaerobic degradation, or it can also be used as a polishing step for a primary groundwater treatment process such as air stripping. Carbon can be used to treat both the liquid and gaseous effluent streams from an air stripper. When applied to the liquid stream, it can remove residual contaminants from the effluent stream which were not removed by air stripping. If the control of air emissions from the stripper is required, carbon is often used as a means to adsorb the volatile organic constituents of interest from the emission stream. Dehumidification is necessary if the emission stream has a high water vapor content (relative humidity greater than 50%), and cooling may be required if the emission stream temperature exceeds 120° to 130°F.

Recommendation: Carbon adsorption will be retained for further consideration.

4.3.5.2 Air Stripping

Air stripping is a process that uses air to scrub volatile organic compounds (VOCs) from a dilute aqueous waste stream into an air stream. The most common design for an air stripping process is a forced-draft countercurrent packed column. The groundwater is pumped to the top of the stripper, sprayed onto the inert packing, and allowed to trickle down the column while air is forced up through the tower by a blower. VOCs, which have an affinity for the gas phase, transfer from the groundwater to the air stream and are exhausted through the top of the tower.

Based on existing NJDEPE policy, an air stripper would most likely require air emission control and permits. Vapor-phase carbon adsorption or fume incineration are common means of emission control.

Air stripping would be an effective and readily available technology for removal of VOCs at the L.E. Carpenter site. For xylene and ethylbenzene, the two VOCs with the highest concentration at the site, air stripping is capable of removal efficiencies in the 99% range. For effective operation of a stripper, the influent groundwater may need to be filtered to remove suspended solids and separated from any nonaqueous (i.e., immiscible) product. Air stripping would not be applicable to the treatment of the floating product layer.

Air stripping would not be effective for treatment of semivolatile constituents, including DEHP. Air stripping is primarily applicable for removal of compounds that have Henry's Law constants greater than approximately 15 atm. Henry's Law constant is a measure of a compound's volatility or, more specifically, the equilibrium distribution coefficient for its concentration in the vapor relative to the liquid phase. The higher a compound's Henry's Law constant, the greater its stripability. At 55°F, the Henry's Law constants of the phthalate compound present at the site are 10^{-2} to 10^{-4} atm, far below the 15-atm rule of thumb, making it unsuitable for treatment by air stripping.

Recommendation: Air stripping will be retained for further consideration as an effective treatment technology for VOCs, which comprise roughly 65% of the total organics mass loading in a groundwater treatment stream. Air stripping may be cost-effective in reducing the mass of contaminants to a subsequent treatment process option. Although air stripping is not effective for DEHP or floating product, it could potentially be combined with other technologies, such as liquid-phase carbon adsorption or advanced oxidation, as part of a Remedial Design alternative.

4.3.5.3 Steam Stripping

Steam stripping is a process by which organic compounds are extracted from the liquid phase by superheated steam. The process is similar to air stripping, except steam is used as the transfer media instead of air. The aqueous stream is introduced at the top of the column and trickles down through perforated trays where the surface area allows for close contact with the steam. Steam and organic vapors are released at the top of the column and the stripped effluent exists at the bottom. The steam and organic vapors are condensed after release from the column.

Stream stripping is applicable to aqueous streams containing higher concentrations (9 to 20%) of VOCs and to compounds less volatile than those removable by air stripping. Compounds exhibiting a low Henry's Law constant may be amenable to steam stripping. However, phthalates and most of the other semivolatiles present at the L.E. Carpenter site do not exhibit Henry's Law constants high enough (i.e., are not volatile enough) to be effectively treated by this technology. The Process Design Manual for Stripping of Organics, issued by EPA's Office of Research and Development, describes DEHP and most of the other phthalates present in the groundwater as "difficult" to treat by steam stripping.

Steam stripping requires extensive energy input. Equipment would include condensers and electric or diesel boilers. As with air stripping, emissions from the steam stripper to the atmosphere may have to be controlled with the use of another technology such as vapor-phase carbon adsorption. Although air emissions would be limited to noncondensable organic vapors, the organic condensate would also require treatment or disposal.

WESTON

Recommendation: On a cost-effectiveness basis, steam stripping can be essentially screened out relative to air stripping as being more cost intensive without a significant improvement in removal efficiency.

4.3.5.4 Membrane Separation

Membrane separation processes utilize semipermeable membranes to separate contaminants from liquids by rejecting contaminants because of the molecular to pore size, ion valence, or coprecipitation. The most common and most developed technique for on-site use is reverse osmosis, which uses a pressure-driven membrane process.

The treatment process yields a purified stream with up to or greater than 99% of contaminants removed, depending on the nature of the contaminants and the membrane selected, and a concentrated stream that requires further treatment. Membranes have a history of excellent performance in removing metals and dissolved solids, but variable performance in removing organics. High molecular weight organics (300 to 500) are most easily removed. Removal of low molecular weight compounds would have to be achieved via another treatment system. Substantial pretreatment is also required to prevent fouling of the membrane by suspended solids and biological growth. High concentrations of iron could result in precipitation of ferric hydroxide on the membrane, which would lead to fouling and decreased effectiveness.

Laboratory and/or pilot-scale treatability studies would be required to confirm the feasibility of and to determine the design and operating parameters for membrane separation. Also, the compatibility of the membrane material with the contaminants must be evaluated.

Recommendation: Membrane separation will not be retained for further consideration for treatment of organics. Membrane separation is retained for further consideration for addition to a selected groundwater treatment train if metals concentrations in treated groundwater effluent exceed remedial goals.

4.3.5.5 Resin Adsorption

Resin adsorption (ion exchange) is conceptually similar to activated carbon adsorption; however, in this process, organic and inorganic molecules are retained within adsorptive resin material through chemical interactions, including ion exchange, dipole-dipole interaction, and hydrogen bonding. Exhausted resin, which contains concentrated contaminants, must be regenerated or be disposed.

In practice, this technology has been widely applied to removal of inorganics. The application of sorptive resins to the types of organics present at this site is less well established. Resins may be tailored to remove specific types of contaminants.

As with activated carbon adsorption, resin adsorption has maximum limits on the influent suspended solids and total constituent concentrations to which it is applicable. The same suspended solids limit and easily implemented solids pretreatment methods apply to both technologies. The technology is applicable to total organics concentration of up to 2,500 ppm, which is considerably less than the effective range of carbon adsorption but still within the range of contaminants found in the groundwater at this site. Another drawback of resin adsorption, which would require treatability testing to define, is that it may not remove all organic contaminants of concern. In addition, resins may be subject to fouling from adsorption of competing species such as oils and hydrocarbons.

Recommendation: For the range of organic contaminants present at the site, resin adsorption is less effective, less versatile, and not as well understood as carbon adsorption. Resin adsorption will not be considered further for treatment of organics. Although concentrations of metals in groundwater treatment influent is anticipated to be below proposed cleanup standards, ion exchange is retained for further consideration for removal of metals above action levels.

4.3.5.6 Liquid Phase Separation

Oil/water separation is used to provide a physical separation of liquids having different phases, utilizing gravity and density differentials. In addition to removing/recovering free-phase material, it can also serve as a pretreatment step for subsequent unit processes for which even small quantities of free oil (or other organics) can be disruptive to process performance (e.g., activated carbon).

Gravity separation can be accomplished in a vessel that allows sufficient holding time and quiescent conditions for the phases to separate. The performance of an oil/water separator can be enhanced by the use of coalescing tubes or plates, which are used to increase the effective surface area of the separator. Gravity-differential separation can also be improved by enhancing the effective density difference (relative buoyancy) using a process such as dissolved air flotation. If required removals cannot be achieved, a polishing step such as sand filtration can be provided. Oil/water separation is not effective in removing dissolved organics.

Oil/water separation is an old and well established technology. There are many types of oil/water separator units commercially available from vendors. The selection of an effective separator depends on sufficient characterization of the organic component(s) of interest, including specific gravity, particle size, and temperature. If these parameters are known, the unit can be sized based on forward flow rate and removal efficiency requirements. This process will not remove dissolved oil, although emulsions can be broken with chemical pretreatment.

With respect to waste streams resulting from oil/water separation, a backwash will be generated if a polishing filter is used, but this can be recycled to the head of the process. The waste stream would consist of the floating product and, possibly, an oily sludge.

Recommendation: Liquid phase separation will be retained for further consideration for use if the groundwater contains some organic phase material following operation of the EIPRS.

4.3.6 Chemical Treatment Technologies

The chemical treatment options to be screened include advanced oxidation and high energy electron beam. Two other forms of chemical treatment, wet air oxidation and supercritical water oxidation, which were evaluated previously as soil treatment technologies, are not discussed in this subsection because they would not be applicable to the relatively low concentration of organics in the groundwater.

4.3.6.1 Advanced Oxidation

Advanced oxidation processes employ a combination of ultraviolet (UV) light and strong oxidants such as hydrogen peroxide (H_2O_2) and ozone (O_3) to degrade organic compounds or oxidize various inorganic species to higher oxidation states such that the inorganic compounds become insoluble in water and can be filtered out.

UV radiation serves to raise constituents such as xylene to a higher energy state. At times, this high energy state may even break or alter some chemical bonds. Generally, the increased energy state makes the molecules more receptive to oxidation. The most important function of UV radiation is to enhance the formation of free radicals which oxidize and degrade the organic constituents of interest. The free radical that is produced depends on the oxidant used. Hydrogen peroxide produces a hydroxyl radical, and ozone produces an oxygen radical. These powerful oxidants then react with the subject molecules. When the reaction is taken to completion, the products of degradation of organic molecules are carbon dioxide (CO_2) and water (H_2O). The intermediate by-products of reaction would likely exhibit lower toxicity than the original organic constituents, and therefore may be acceptable in the discharge stream if complete reaction is not realized.

For UV/H_2O_2 systems, the process design is basic. Hydrogen peroxide is metered out of a storage tank and combined with the aqueous stream to be treated. This stream is then sent to a UV chamber where it is exposed to ultraviolet light (or radiation) for an appropriate retention time prior to exiting from the chamber.

UV/O_3 systems may be designed similarly to UV/H_2O_2 systems. In UV/O_3 systems, wastewater is sent to a UV chamber where ozone gas is bubbled through the water. However, such systems do not provide much surface area for ozone/organic compound contact. There have been some recent improvements in the design of UV/O_3 systems. The advantage of the improved design is that the intimate contact between O_3 and the organic compounds results in a lower UV dosage requirement. Consequently, fewer UV lamps at a lower wattage would be required to achieve the same destruction efficiency as the high-powered UV/H_2O_2 systems.

The equipment requirements for aqueous waste treatment are relatively simple. These include: enclosed tanks constructed of materials capable of withstanding oxidant attack to serve as reaction vessels, metering pumps, and storage tanks for reagents/reactants.

Since the reactions occur in a closed vessel and the products of complete reaction are virtually nontoxic, air emissions are not a significant concern. One limiting factor in implementing this technology is the turbidity of the extracted influent groundwater. Groundwater turbidity will be dependent upon the extraction procedure used at the site. Wells, screens, pumping rates, and degree of groundwater disturbance prior to removal are all contributing factors. UV light must be able to penetrate the water so that the subject compounds are exposed to the radiation. Therefore, very turbid water would significantly reduce the process effectiveness and must be prefiltered. Dissolved solids in the water to be treated will also adversely affect performance by causing fouling of the UV lamps.

Mobile advanced oxidation units can be engineered for field applications. Prior to implementation of these systems at a site, laboratory bench-scale or pilot-scale testing is necessary to determine operational and design parameters for application to DEHP. Advanced oxidation processes have been proven successful in the treatment of groundwater containing xylene and ethylbenzene.

Recommendation: Advanced oxidation processes will be retained for further consideration.

4.3.6.2 High-Energy Electron Beam

This process uses an electron accelerator to irradiate aqueous streams or sludge; the purpose is to either act as a bactericide to disinfect the water, or to decompose organic compounds in order to reduce toxicity. Decomposition is caused mainly by hydroxyl radicals, one of three highly reactive species produced by irradiation of water. The process is still in the experimental stage, so the physical configuration of a field unit has not been developed. One advantage of this technology is that it can work on dilute as well as concentrated streams. It does not generate residual radiation; radiation is only produced while the unit is powered. Pilot studies have shown that an electron beam can be used to decompose halogenated organics and phenols. Bench-scale and pilot studies would be necessary to determine the effectiveness of this technology on DEHP, xylene and ethylbenzene. This technology is still in the laboratory stage and appears at least several years from being commercially available.

Recommendation: The high-energy electron beam technology will not be retained for further consideration.

4.3.7 Biological Treatment Technologies

Biological treatment technologies use microorganisms to detoxify or decompose biodegradable organics. Naturally occurring (native) species may be utilized, or specially adapted microorganisms may be introduced into the contaminated media. Ideally, biological treatment will reduce contaminants to concentrations that will preclude the need for application of additional treatment technologies.

4.3.7.1 Aerobic Biological Treatment

Aerobic biological treatment utilizes microorganisms to break down or decompose biodegradable organic compounds by oxidation or hydrolysis in the presence of oxygen. This technology can be implemented in a variety of reactor systems ranging from suspended growth to fixed film systems. The characteristics of the waste stream (organic types and concentrations) basically determine what types of reactors are applicable.

Biological reactors can often be used to effectively treat groundwater because of their relatively stable operating parameters. An on-site laboratory may be required to ensure careful monitoring and steady operation.

Settled sludge or excess biomass from process operations may contain elevated levels of nondegradable organic or inorganic compounds. Sludge will require dewatering and may be shipped off site for treatment or disposal. Acceptance from the treatment and disposal facility will be needed prior to shipment.

Biological reactors have been used effectively to treat aqueous waste streams contaminated with nonhalogenated organics. Numerous sources in the literature indicate that DEHP is amenable to biological degradation, although not as readily as xylene and ethylbenzene. Preliminary treatability studies on site samples indicate this process is effective. Pilot-scale testing (possibly in the Remedial Design phase) would determine the final configuration for the system, the treatment levels for the organic compounds of interest and the requirements for supplemental nutrient addition. In addition, if biological treatment does not directly achieve targeted cleanup levels, then other technologies such as carbon adsorption or membrane separation may be used as a polishing step.

Recommendation: Aerobic bioremediation will be retained for further consideration.

4.3.7.2 Anaerobic Biological Treatment

In contrast to aerobic biological treatment, where organic compounds can ultimately be degraded to carbon dioxide and water in the presence of oxygen, anaerobic biological treatment involves the microbial breakdown of organic compounds to carbon dioxide and methane gas, hydrogen gas, organic acids, alcohols, amines and a small quantity of excess biomass in the absence of oxygen.

As with aerobic treatment, suspended-growth processes and attached-growth processes are the primary anaerobic methods in common use. Suspended growth processes occur in an airtight reactor where the biomass and water to be treated are mixed. If a high-rate reaction is desired, the contents of the reactor are heated.

The primary attached-growth anaerobic process is called an anaerobic filter. It consists of a column filled with solid media on which anaerobic microorganisms grow. The aqueous stream flows through the column to contact the microbes, which degrade the organic compounds. As with suspended growth systems, elevated temperatures may be used.

The advantage of anaerobic biological treatment over aerobic treatment is that it can more economically treat higher concentration aqueous wastestreams, degrade certain recalcitrant organic compounds, and normally generate a lower volume of sludge eventually requiring disposal. However, research literature indicates that DEHP is far less amenable to anaerobic than to aerobic degradation.

An additional disadvantage of anaerobic biological treatment compared to aerobic biological treatment is that it is more sensitive and susceptible to changes in stream characteristics, which can cause shock loading and interfere with the biological process. Methane gas is generated as a by-product of the anaerobic process and it must be carefully monitored to protect the local environment. Also, anaerobic processes are fermentive and may not produce environmentally acceptable products. Therefore, it may be necessary to combine anaerobic with aerobic processes to facilitate degradation to acceptable products of treatment. Retention times are typically longer for anaerobic processes than for aerobic processes.

Bench-scale and pilot-scale testing would be required to determine treatment effectiveness on the subject groundwater. Anaerobic processes are usually amenable to higher concentration waters, so their applicability to a dilute aqueous stream will have to be determined.

Anaerobic treatment systems would be designed for field applications. At start-up, a transportable system would require sludge seeding and acclimation prior to achieving effective process performance. As with aerobic systems, careful monitoring of process parameters is required and an on-site laboratory may be needed.

Recommendation: Based on information in the research literature, anaerobic bioremediation is dropped from consideration in favor of aerobic bioremediation.

4.3.7.3 Spray Irrigation

Spray irrigation incorporates aspects of biological as well as physical and chemical treatment. Extracted groundwater is sprayed on the targeted remediation zone. This facilitates contaminant removal from groundwater through aeration of volatiles, bacterial decomposition in the upper soil layers, adsorption on the soil particles, and uptake by plants. It would also foster in situ treatment, and in particular, may be a suitable method to in situ treatment of vadose zone soils. Difficulties with spray irrigation include odors and VOC emissions, possible toxicity to plants, community acceptance, freezing, and land availability. It is also not applicable to areas which are paved or otherwise covered. Aboveground bioreactor treatment prior to irrigation may be appropriate.

Recommendation: Spray irrigation will not be retained for further consideration due to limited land area and regulatory limits on air emissions.

4.3.7.4 Treatment of Contaminated Water by Natural Attenuation in Manmade Wetlands

Manmade wetlands are used to remove contaminants from collected groundwater and surface water by means of natural processes. Gently sloping beds are excavated, lined with an impermeable barrier, and planted with emergent hydrophytes such as reeds, brush, or cattails. In general, the beds have an inlet zone of large crushed rock to distribute the wastewater evenly over the width of the bed and an outlet zone of crushed stone.

The concentration of nutrients, heavy metals, pesticides, and other natural and manmade organics have been shown to be significantly reduced in wastewater applied to constructed wetlands. High plant productivity, large adsorptive surfaces on sediments and plants, aerobic-anaerobic interface, and most importantly, an active microbial population contribute to the wastewater renovation. Wetland treatment systems have been shown to be simple to control and maintain, able to withstand a wide range or operating conditions, and to have relatively low energy and manpower requirements. A principal disadvantage for constructed wetlands is that very large land areas are required for implementation.

This technology might be favored if groundwater collection proves ineffective and surface water presents a potential risk to receptors on Rockaway River.

Recommendations: This technology will not be considered further due to the limited availability of open land.

4.3.8 <u>In Situ Treatment Technologies</u>

4.3.8.1 In Situ Biodegradation

In situ biodegradation, discussed previously in Subsection 4.2.9.1, degrades groundwater as well as soil contaminants in situ. This technology, as applied to groundwater remediation, involves extracting groundwater and recirculating it, along with added oxygen and nutrients, back to the upgradient side of the contaminated area. Recharge of groundwater may be accomplished via surface (i.e., spray) irrigation, a series of subsurface perforated piping or drain field, similar in design to a septic leach field. This design allows for percolation of treated groundwater through vadose zone soils to the water table. Typically, the extracted groundwater receives additional treatment, such as aboveground biological treatment or carbon adsorption, before reinfiltration.

Recommendation: In situ biodegradation is retained for further consideration.

4.3.8.2 Permeable Treatment Beds

Permeable treatment beds, also referred to as in situ adsorption, consist of excavated trenches placed perpendicular to groundwater flow that are filled with material to treat or adsorb the contaminants. This technology represents a passive scheme to remove and treat contamination in the groundwater.

Permeable treatment beds are applicable to shallow groundwater aquifers. Studies point to the application of this technology as a temporary or short-term remedial action, but it is still in the developmental phase. Materials used as adsorbents include activated carbon, limestone, glauconitic green sand, and zeolites. Permeable treatment beds are often effective only for short time because they lose reactive capacity or become plugged with solids. Over-design of the system or replacement of the permeable medium can lengthen the effective life of a bed.

Installation of a permeable treatment bed is relatively simple. Placement and orientation of the treatment bed to ensure maximal capture of groundwater flow are critical factors in implementation. For sites such as this one, where bedrock or an impermeable clay layer are too deep to key into, permeable treatment beds are only minimally effective.

Costs for implementing this technology are generally dependent upon the areal extent and depth of the contaminated plume and the replacement/treatment costs for spent adsorbent; however, they are generally lower than other on-site treatment technologies.

Recommendation: Permeable treatment beds will not be retained for further consideration because they address only the uppermost section of the aquifer. As a technology for the control of the floating product layer, other collection and containment technologies (e.g., skimming, collection trenches, or slurry walls) are more effective and permanent.

4.3.9 Groundwater Discharge

The options for the disposition of groundwater include surface water discharge, discharge to a POTW, or groundwater reinfiltration. Compliance with New Jersey Pollutant Discharge Elimination System (NJPDES) permitting procedures would be required for each of the options. Treatment of the groundwater prior to discharge may also be required as determined by the influent characteristics and permit limits.

4.3.9.1 Discharge to Surface Water

The effluent concentration limits and allowable discharge volumes will be based on protecting the water quality of the receiving water. Discharge to surface water may be accomplished by discharging either directly to the Air Products drainage ditch or the Rockaway River, or, indirectly, through a storm drain. Discharges to surface water must meet all applicable NJDEPE requirements.

Recommendation: Discharge of groundwater to surface water is retained for further consideration.

4.3.9.2 Discharge to a Publicly Owned Treatment Works (POTW)

Discharge to the RVRSA would require compliance with NJPDES Significant Industrial User (SIU) permitting procedures, including endorsement by RVRSA. As discussed in Section 2, an inquiry to RVRSA to determine if they have the necessary capacity available determined that RVRSA has a firm policy of not approving any new discharges from groundwater remediation projects even after pretreatment.

Recommendation: Based on RVRSA current policies, discharge of groundwater to a POTW is dropped from consideration.

4.3.9.3 Groundwater Reinfiltration

Under New Jersey groundwater discharge requirements, primary groundwater standards and corrective action criteria (developed specifically for the site through the New Jersey Pollutant Discharge Elimination System (NJPDES) Discharge to Groundwater (DGW) permit process) will determine allowable discharge levels. Discharge levels may be adjusted upward if it can be shown that the reinfiltration point(s) is (are) upgradient of the extraction point(s) and all reinfiltrated groundwater is contained by the extraction network.

Groundwater reinfiltration may be accomplished through wells, drain fields, or infiltration galleries, which are used to recharge groundwater via seepage. Infiltration galleries consist of excavated areas backfilled with gravel or other media which exhibit acceptable hydraulic transmissivity, on which a perforated distribution line is laid. The gravel is covered by topsoil, which is separated from the gravel by a geotextile fabric. Infiltration galleries must be maintained to prevent clogging. Drain fields are distribution systems with porous or perforated piping used to allow the reinfiltrated groundwater seep into vadose zone soils at a slower rate and over a wider area than would be accomplished by infiltration galleries. Like infiltration galleries, drain fields are covered by topsoil to protect the piping from breakage and for aesthetic purposes.

Recommendation: Groundwater reinfiltration is retained for further consideration.

4.4 SUMMARY OF THE TECHNOLOGY SCREENING

The following tables (Table 4-2 for soils and Table 4-3 for groundwater and immiscible product) summarize the screening and evaluation of technologies potentially applicable to the L.E. Carpenter site.

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SECTION 5.0

DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

In Section 4, various technologies were screened for their applicability to the remediation of the L.E. Carpenter site. In this section, these technologies are assembled into remedial alternatives. Because the purpose of the screening evaluation is to reduce the number of alternatives that will undergo a more thorough and extensive analysis, alternatives will be evaluated in more general terms in this section than in the detailed analysis (Section 6). However, the screening evaluation will be sufficiently detailed to distinguish among alternatives.

Prior to the development and screening of remedial alternatives, a discussion of operable units for the L.E. Carpenter site has been provided. The operable units are separable components of potential comprehensive site alternatives. The operable units have been defined as:

- DEHP contaminated soils.
- Isolated hot spot soils
  - Lead
  - Antimony
  - PCBs
  - Disposal area
- Immiscible product.
- Groundwater.

5.1 DEHP CONTAMINATED SOILS

This operable unit is defined as the approximately 13,500 yd^2 area which exceeds the DEHP NJDEPE draft Soil Cleanup Criteria generally extending from the east of former Buildings 13 and 14 onto the Wharton Enterprises property. This operable unit also includes isolated unexcavated soils in the vicinity of the former underground storage tanks E5 and E8.

The primary contaminant in this area is DEHP, which is present at the highest concentrations in soils near the immiscible product layer 3 to 5 ft below ground level. The soils also contain xylene and ethylbenzene, but the calculated risk for these compounds was below a hazard index of 1.0. For remedial alternatives requiring soil removal, excavation would be completed to the full vertical extent of contamination above soil cleanup standard levels to a maximum depth of 1 ft below the lowest water table elevation historically observed at that location.

In soils nearer the surface, the level of contamination was significantly less. Soils contaminated by the former impoundment area were removed to a reported depth of 8 to 12 ft as part of the 1982 excavation of this area.

Therefore, the current levels of contamination are primarily the result of fluctuations in the groundwater table which has caused the immiscible product to rise into, and sorb to, the overlying soil. As such, removal of the remaining immiscible product layer should reduce the levels of contaminants in the soils, and any effort to remove the soil contamination prior to removal of the immiscible product would be ineffective.

The primary objective of remediation of this operable unit is to facilitate the remediation of groundwater, which is the primary contaminant transport mechanism. The soil remediation itself is potentially the most difficult and capital intensive component of the overall site cleanup. For this reason, the remedial technology selected for this operable unit is the primary difference between each of the comprehensive site alternatives. For DEHP-contaminated soil, the primary technologies retained for development of comprehensive site alternatives are:

- Soil cover.
- In situ biodegradation.
- Soil washing (followed by bioslurry treatment).
- Incineration

Several technology process options retained for further consideration from the initial technology screening in Section 4, wet air oxidation, supercritical water oxidation, and in situ volatilization, were not developed into alternatives because these technologies are unproven for DEHP and are unlikely to be effective for the average concentration of DEHP in this area. Wet air oxidation and supercritical water oxidation require minimum organics concentrations in the range of 1,000 ppm and 20,000 ppm, respectively, to make the oxidation reaction self-sustaining. Based on the expected aggregate total organic carbon concentrations in the soils or treatment residues from other operations, these technologies have not been included in any remedial alternatives. In situ volatilization is not included in any remedial alternatives because it would be ineffective for DEHP-contaminated soils, and the volatile compounds for which this technology is effective comprise only a small fraction of the contamination.

Incineration was developed as a potential technology for this operable unit; however, some technical difficulties are expected. Dewatering the contaminated soil excavated from the saturated zone would be necessary prior to thermal treatment (unlike soil washing). Dewatering would yield a significant volume of high concentration aqueous waste (potentially containing free product) which will require further treatment. Permitting requirements and strong local opposition to siting a transportable incinerator at the L.E. Carpenter site for on-site thermal treatment of soils can be expected. Furthermore, commercial RCRA-permitted hazardous waste incinerators are currently operating at or near capacity and may be reluctant to accept large volumes of materials that exhibit generally poor burn characteristics (low Btu and high ash concentrations). Lastly, incineration of soils would be more difficult to implement and less cost-effective than soil washing, which has also been retained for detailed analysis.

An inherent difficulty in applying incineration, soil washing, or any other ex-situ treatment technology is in excavating large volumes of soils. The high water table, proximity to the 100-

year and 500-year floodplain, the adjacent wetlands on Wharton Enterprises property, and the adjacent Rockaway River all contribute to the impracticality of large scale excavation. Earthmoving techniques increase the mobility of sediments and minute soil particles which may cause sedimentation in the wetlands, as well as increased sediment loading to the Rockaway River. Excavation and staging of soils from below the water table could increase the likelihood of overland flow of contaminants in the saturated soils to the river or wetlands. Excavation within a floodway or flood fringe area could alter its beneficial ability to control and direct floodwaters.

5.2 ISOLATED HOT SPOT SOILS

Isolated areas of the site soils are contaminated with chemicals requiring remediation, namely, lead, antimony, PCBs, and contamination associated with the recently identified disposal area in the northeastern corner of the site. The major contaminants in the fill in the disposal area were xylenes and ethylbenzene. The soil in the disposal area was not sampled.

Remediation of each hot spot would proceed until the cleanup standards for each contaminant of concern were achieved. Verification sampling would follow any removal action. In addition to the soil cleanup standards presented in Table 2-7 for DEHP, lead, antimony, and PCBs, cleanup in the disposal area may be necessary for xylenes (standard = 10 mg/kg), and ethylbenzene (standard = 100 mg/kg).

Since the hot spot contamination is rather isolated, excavation of the contaminated areas may be the most effective, implementable, and cost-effective remedial technology. Treatment of soil from each isolated area for the individual contaminants of concern would not be cost effective due to the low soil volumes. If the hot spot soils are not hazardous or not placed (i.e., moved outside of the area of contamination) for disposal, LDRs would not apply. However, the LDRs will constrain placement or off-site disposal of the material without treatment if the soil is considered to be a listed or characteristic hazardous waste. For example, the LDR criteria for DEHP and xylene are 28 mg/kg each and these compounds may be present in the metals hot spots. Therefore, treatment technologies such as soil washing, solid phase bioremediation, and incineration are applicable to isolated hot spot soils. If incineration is used to treat soils from lead hot spots, the ash will likely need to be stabilized to assure the lead does not leach from the ash. Antimony does not have a TCLP maximum limit. In addition, capping or in situ treatment technologies would be attractive options for the isolated hot spot soils because these actions are not constrained by the LDRs.

The ultimate disposition of each of the isolated hot spot soils depends on the chemical composition, classification as a hazardous or nonhazardous waste, treatment technology applied, and regulatory interpretation. A summary of the options for the disposition of these soils is presented in Figure 5-1.

5.3 IMMISCIBLE PRODUCT REMOVAL

An integral part of an acceptable remedial alternative involves the immiscible product be removed to the maximum extent possible. This should occur in the early phases of a comprehensive site remediation for the following reasons:

- The remediation time and operating costs of groundwater treatment technologies are a function at least of the organics concentrations in the extracted groundwater. The concentrations of the organic contaminants in the uppermost portion of the shallow groundwater zone are not likely to decrease from current levels as long as an immiscible product layer is present. Contaminant removal can be achieved more cost effectively via removal of the concentrated immiscible phase than via removal of a dissolved constituent in groundwater;

- For the in situ biodegradation alternative, microbial activity in the immiscible product zone of the soil would be low because biodegradation requires an aqueous environment; and,

- For remedial alternatives involving excavation, immiscible product in an open excavation would cause potential safety hazards and emissions of volatile organics.

The Enhanced Immiscible Product Recovery System currently collects product passively at six wells. The passive product recovery rate is currently approximately 13 gpd. Active recovery (skimming and groundwater extraction) using either additional collection wells or a trench system could be implemented when passive product recovery is no longer feasible with the EIPRS system and after receiving approval to discharge treated groundwater. Groundwater extraction from product recovery trenches or wells is essential to produce a hydraulic gradient to accelerate removal of the immiscible product.

An enhancement to the current passive recovery system has been proposed. Three large diameter caisson wells are to be installed within the area of free product in order to maximize the current recovery of product for the site. Large diameter caissons were selected over recovery wells and/or trenches for several reasons. The large storage volume afforded by caissons allow for recovery of larger volumes of product than would smaller diameter recovery wells. Installation of caissons require significantly smaller volumes of soil than would recovery trenches. Caisson wells can serve dual purposes for both passive free product recovery and active groundwater recovery, if required. Further, caisson wells may be utilized as sumps for a groundwater/product recovery trench, if that option is determined to be more feasible than a series of extraction wells.

5.4 GROUNDWATER COLLECTION AND CONTAINMENT

5.4.1 Development of the Initial Groundwater Collection System

The screening of groundwater collection options is governed by considerations similar to those for the immiscible product removal system. The conceptual groundwater collection systems discussed in this FS provide for an estimation of groundwater treatment system influent mass loading, treatment feasibility, approximation of capture zone, and as a basis for cost estimation. The actual number and locations of pumping wells, as well as pumping rates, will be determined during Remedial Design.

The approximate areal extent of the dissolved volatile and semivolatile organic compound plumes are presented in Figures 1-6 and 1-7. Because the data upon which the figures are based represent samples collected from beneath a floating product layer, the data shown are conservative maximum concentrations which would likely exceed any influent concentrations requiring treatment. The approximate areal extent of the immiscible floating product is presented in Figure 1-4.

Groundwater remediation will be accomplished in two steps or phases. Phase I will involve active immiscible product removal with either recycling or treatment of extracted groundwater. Phase II will involve extraction and treatment of groundwater contaminated with dissolved organics.

Groundwater flow modeling was performed to simulate two specific phases of groundwater extraction/recirculation at the L.E. Carpenter site. The first phase (hereafter referred to as Phase I Extraction/Recirculation) involved groundwater pumping and recirculation (recycling) to facilitate the active recovery of immiscible floating product at the site. The second phase of groundwater extraction/recirculation (hereafter referred to as Phase II Extraction/Treatment) involves the pumping of groundwater to recover groundwater contaminated with dissolved phase constituents.

Groundwater extraction and recirculation at the L.E. Carpenter site was simulated to support development of the cost assumptions presented in Section 6 of this report. The results of groundwater flow model simulations intended to provide general estimates of the effectiveness of extractive/reinjective technologies. More detailed analyses will be required as part of the RD for a remedial action involving the extraction or recirculation of groundwater.

These two phases of groundwater remediation incorporate no discharge to surface water. Groundwater will be recycled on site through reinfiltration/recirculation to realize the maximum beneficial use of treated groundwater for plume control and soil treatment.

5.4.2 Estimate of Treatment System Influent Concentration

In order to better evaluate the groundwater treatment options, the initial composition of the groundwater influent to a treatment system was estimated for the six-well groundwater collection system simulated to support development of cost assumptions. This rough estimation of the initial influent concentrations to the treatment system is based on a flow-weighted average of the RI groundwater sampling results (mean) for the monitoring well nearest to the proposed extraction well. The mean of all rounds of analytical results for each contaminant and each well of concern were used. Initial modeling indicated that flows from each well will be roughly the same, therefore, a simple average concentration was utilized.

Based on this estimate presented in Table 5-1, the initial groundwater concentrations would be approximately 16, 55, and 10 ppm for DEHP, xylene, and ethylbenzene, respectively.

This estimation of the initial organics loading to the treatment system establishes a rough approximation of potential treatment system influent. Modifications to the relative pumping rates could change the composition of the treatment system influent substantially. Because the groundwater samples from two of the highest concentration wells (MW-6 and MW-10) were sampled immediately below the immiscible product layer without purging the monitoring well, these results may be upwardly biased. After the start of pumping, the groundwater concentrations are expected to decrease until steady state levels are achieved. Because of these uncertainties, an aquifer pumping test will be essential in establishing a basis for treatment selection and design.

The groundwater analytical results indicate that DEHP is present at concentrations considerably above its water solubility of 0.3 ppm. For the purposes of evaluating treatment systems, it is assumed that the DEHP has been solubilized by the xylene and ethylbenzene. The DEHP may actually be present in the form of suspended immiscible product. If this is the case, an oil/water separator could be added as a pretreatment step to remove the immiscible product, which is a mixture of DEHP, xylene, ethylbenzene, and other hydrocarbons. However, if the DEHP component alone is present in suspension, an oil/water separator would not be effective because the specific gravity of DEHP, 0.99, is too similar to that of water to allow for physical separation.

For the most part, introduction of free phase or suspended immiscible product into the groundwater treatment system can be minimized by proper design of extraction techniques and pumping systems (i.e., adequate phase separation interval, appropriate screen sizing, and sufficient pump intake travel). Therefore, the use of an oil-water separator is not included as part of any remedial alternative.

5.4.3 Groundwater Treatment Options Screening

In Section 4, three technologies were identified as potentially applicable for treatment of contaminated groundwater. These technologies are: 1) carbon adsorption, 2) advanced oxidation, and 3) aerobic biological treatment. Air stripping was also identified as an effective ancillary technology for reducing the mass loading of volatile organics to subsequent treatment units. Based on the relatively high estimated concentration of semivolatile compounds in the treatment system influent, the air stripping (with vapor phase treatment) would be less cost effective than the other treatment technologies under consideration. However, these economics could shift based on the outcome of the aquifer pumping test. Similarly, membrane separation and resin adsorption, which would be effective for metals removal, would not address organic contamination.

As discussed in Section 4, all three of the primary groundwater treatment options under consideration would be effective for the organic groundwater contaminants of concern. All three are demonstrated technologies, although some treatability testing would be necessary to establish removal efficiencies and operating parameters, particularly for advanced oxidation and aerobic biological treatment. Furthermore, all three options are anticipated to be capable of meeting chemical-specific ARARs if a carbon adsorption unit is included as a polishing treatment step. It is anticipated that the constraining effluent limit would be the groundwater cleanup standard of 30 ug/L for DEHP.

For the purposes of developing comprehensive site alternatives, aerobic biological treatment followed by carbon adsorption is selected as the representative treatment technology based on its cost-effectiveness. This treatment option will be carried through detailed analysis as the groundwater treatment component. However, as concentrations of organics in the groundwater decrease over time, the organic food source may become insufficient to support microbial degradation. At that time, the aerobic biodegradation system can be replaced by another treatment option. Carbon adsorption is the logical choice, since the system would already be on-line (as the polishing step) and the technology is effective at low organic concentrations.

5.5 DEVELOPMENT OF COMPREHENSIVE SITE ALTERNATIVES

Based on the previous discussion of each operable unit and the most appropriate technologies, the remedial alternatives for each operable unit have been combined into the following comprehensive site alternatives:

- Alternative 1 - No Action
- Alternative 2 - Institutional Controls
- Alternative 3 - Groundwater Treatment
- Alternative 4 - Groundwater Treatment with Reinfiltration
- Alternative 5 - Excavation/On-Site Soil Washing/Bioslurry Treatment
- Alternative 6 - Excavation/Thermal Treatment

Alternative 1, which is carried forth as required under the NCP, involves no remedial actions other than the ongoing monitoring and passive product recovery activities. Alternative 2 proposes restrictions on the future use of the property and an expanded monitoring program. Alternative 3 includes all features in Alternative 2, as well as groundwater containment, collection, and treatment and covering of contaminated surface soils. Alternative 4 includes all parts of the closure alternative and infiltration of amended treated groundwater to stimulate desorption and biodegradation of DEHP adsorbed to soils. Alternative 5 involves excavation of the east site operable unit followed by soil washing. Alternative 6 is the same as Alternative 5, but with incineration replacing soil washing. These alternatives are summarized in Table 5-2.

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SECTION 6.0

DETAILED ANALYSIS OF ALTERNATIVES

The detailed analysis of alternatives consists of the analysis and presentation of relevant information required to allow decision makers to select a site remedy. In this detailed analysis, each alternative under consideration has been evaluated against the evaluation criteria specified in Subsection 6.1.

The alternatives were first independently analyzed without consideration of the other alternatives. The results of this analysis are presented in Subsection 6.2. A comparative analysis was then conducted to evaluate each alternative's relative performance in relation to the specific evaluation criteria. The results of this comparative analysis are presented in Subsection 6.3.

6.1 EVALUATION CRITERIA

In accordance with the NCP and EPA Superfund guidance documents, the following seven criteria were utilized for evaluation of each of the developed site alternatives that were selected for detailed analysis and represent the basis for comparing these alternatives:

- Compliance with ARARs.
- Short-term effectiveness.
- Long-term effectiveness and permanence.
- Overall protection of human health and the environment.
- Reduction of toxicity, mobility, and volume of contaminants.
- Implementability.
- Cost.

Two criteria (compliance with ARARs and overall protection of human health and the environment) are categorized as threshold criteria in that each alternative must meet them (or a variance obtained). The other five criteria are categorized as the primary criteria upon which the analysis is based.

All seven criteria are further discussed below, while the detailed analysis of each alternative is presented in subsequent sections. Two additional criteria, state acceptance and community acceptance, will be addressed in the Record of Decision after the FS has been finalized.

6.1.1 Compliance with Applicable or Relevant and Appropriate Requirements

This criterion is used to determine how each alternative complies with ARARs, as presented in Section 2. The chemical, location, and action-specific requirements are discussed along with any other appropriate criteria, advisories, and guidance as they apply to each alternative.

6.1.2 Short-Term Effectiveness

This evaluation criterion involves consideration of the short-term effectiveness of the alternative during construction and implementation. The evaluation focuses on the protection of the community and the on-site personnel during implementation of remedial measures, potential human health and environmental impacts, and the time required to achieve remedial response objectives.

6.1.3 Long-Term Effectiveness and Permanence

This evaluation criterion involves consideration of the long-term effectiveness and permanence of the alternative once it has been implemented. The evaluation focuses on defining the extent and effectiveness (adequacy and reliability) of the controls that may be required to manage the residual risk remaining from untreated waste and/or treatment residues. Alternatives that afford the highest degrees of long-term effectiveness and permanence are those that leave little or no waste remaining at the site such that long-term maintenance and monitoring are unnecessary and reliance on institutional controls is minimized.

6.1.4 Overall Protection of Human Health and the Environment

This evaluation criterion involves consideration of the overall protection of human health and the environment. The overall assessment of protection draws on the assessments conducted for other evaluation criteria, particularly long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

Evaluation of the overall protectiveness of an alternative focuses on achievement of remedial action objectives and how risks posed through potential exposure routes are eliminated, reduced, or controlled through treatment, engineering, or institutional controls. This evaluation also allows for consideration of whether an alternative poses any unacceptable short-term or cross-media impacts.

6.1.5 Reduction of Toxicity, Mobility and Volume of Contaminants

Consideration of this evaluation criterion is a result of the regulatory preference for selecting remedial actions that permanently and significantly reduce the toxicity, mobility, and volume of the contaminants and associated media.

The following factors are considered in this evaluation:

- The treatment process and materials to be treated.
- The amount of hazardous materials to be treated.
- The degree of expected reduction in toxicity, mobility, or volume.
- The degree to which treatment will be irreversible.
- The type and quantity of treatment residuals that remain after treatment.

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6.1.6 Implementability

This criterion establishes the technical and administrative feasibility of implementing an alternative. Technical aspects evaluated for each alternative include: ability to construct and operate the technologies involved; reliability of the technologies involved; ease of undertaking additional remedial action; and ability to monitor the effectiveness of the remedy after completion of activities. Administrative concerns include establishing contact with appropriate agencies to implement remedial actions (e.g., obtaining approval for construction and operation of a treatment unit, and coordination with various agencies). Availability of materials and services needed is another factor considered, specifically with respect to availability of: treatment, storage, and disposal facilities; necessary equipment and specialists; and prospective technologies.

6.1.7 Cost

A remedial program must be implemented and operated in a cost-effective manner and must mitigate the environmental and human health concerns at the site. In considering the cost-effectiveness of the various alternatives, the following categories are evaluated:

- Capital Costs - These costs include direct (construction) and indirect (nonconstruction and overhead) costs. Direct costs include expenditures for equipment, labor, and materials necessary to install remedial actions. Indirect costs may be incurred for engineering treatability testing, permitting, construction management, or other services not directly involved with installation of remedial alternatives, but necessary for completion of this activity.

- Operating and Maintenance (O&M) Costs - These costs include post-construction expenditures incurred to ensure effective implementation of the alternative and monitoring expenditures. Such costs may include, but are not limited to, operating labor, maintenance materials and labor, rental equipment, auxiliary materials (e.g., chemicals), energy (fuel and electricity), disposal of residues, administrative and insurance costs, groundwater sampling and analytical work, and permit compliance monitoring.

A present worth analysis is utilized for the cost evaluation utilizing a discount rate of 5% as recommended under the Superfund Program. Cost sensitivity concerns are identified and discussed as required for each alternative.

The cost estimates presented in this report are order-of-magnitude level estimates. These costs are based on a variety of information, including estimates from suppliers, construction unit costs, vendor information, conventional cost estimating guides,and prior experience. The feasibility study-level cost estimates shown have been prepared for guidance in project evaluation comparison, and selection based on the information available at the time of the estimate. The costs of the selected alternative will be able to be estimated to a greater level of accuracy after pilot study treatability tests have been completed. The actual costs of the project will depend on true labor and material costs, actual site conditions, competitive market conditions, final project scope, implementation schedule, and other variable factors. A significant uncertainty that would affect the cost is the actual volume of contaminated materials. Most of these uncertainties would similarly affect all of the costs presented in this feasibility study. Therefore, alternatives are internally comparable.

The capital cost estimates do not include the cost of remedial actions already completed or underway such as the enhancements to the product recovery system, building asbestos removal, decontamination and demolition, tank removal, or the installed site-perimeter fence. However, ongoing expenses such as groundwater monitoring and immiscible product disposal are included as O&M costs. The cost of NJDEPE and/or EPA oversight has not been included.

To calculate the net present cost of each alternative, it was necessary to make certain assumptions regarding the total duration of groundwater treatment and immiscible product recovery as well as the reduction of groundwater treatment O&M and discharge monitoring requirements over time.

It was assumed that the total duration of groundwater treatment and monitoring was 30 years for Alternatives 1, 2, and 3 and 20 years for Alternatives 4, 5, and 6. For the last three alternatives the duration of groundwater treatment was assumed to be less (20 years versus 30 years) because these alternatives include treatment of soil contaminants which could otherwise be continuing contributors to groundwater contamination. The discharge monitoring frequency was assumed to be weekly for the first year and monthly thereafter. For Alternatives 3, 4, 5 and 6, it was assumed that immiscible product had been removed to its minimum recoverable thickness after three years of operation, at which time skimmer O&M and immiscible product disposal costs cease. Groundwater treatment costs were assumed to decline over time as concentration dependent costs (e.g., carbon utilization) decrease and the treatment system operating conditions change. As a simplification, these time-dependent O&M costs were expressed as either short-term (defined as years 0 to 3), mid-term (defined as years 4 to 6) or long-term (defined as years 7 to end of remediation) costs.

These estimated times used in the net present cost calculations were based on the typical expected duration of these activities and should not be viewed as forecasts or relative indicators of the extent of remediation. The actual remediation time will depend on the degree to which the various operable units can be addressed concurrently and on the cleanup criteria adopted.

6.2 INDIVIDUAL ANALYSIS OF ALTERNATIVES

6.2.1 Alternative 1: No Action

6.2.1.1 Description of Alternative

The no action alternative provides the baseline for comparing existing site conditions with other proposed alternatives and estimating the potential risk to humans or the environment in the RA.

Under the no action alternative, no additional remedial actions would be initiated beyond the passive operation of the EIPRS and the groundwater monitoring program as specified in the amended ACO. The recovered immiscible product is incinerated off site. The existing monitoring program includes quarterly sampling of monitoring wells MW-4, MW-14s, MW-22 and MW-25, semiannual sampling of monitoring well MW-15s, and quarterly measurements of the water level and floating product thickness for every well at the site. The groundwater samples are analyzed for benzene, toluene, ethylbenzene and xylenes by EPA Method 602.

6.2.1.2 Compliance with ARARs

The RI results indicate that selected contaminants in groundwater exceed federal MCLs and New Jersey MCLs. Some levels also exceed proposed NJDEPE groundwater cleanup standards, which are TBCs. Action-specific requirements of note include RCRA container storage requirements.

6.2.1.3 Short-Term Effectiveness

As the no action alternative does not involve construction or implementation of further remedial actions at the site, this criterion would not apply.

6.2.1.4 Long-Term Effectiveness and Permanence

Under the no action alternative, current contamination would be left in place and changes in contaminant levels would consist of those resulting from natural attenuation process such as leaching, weathering, and biodegradation, as well as from the product recovery system currently in place. Therefore, the residual risk under this alternative is essentially the baseline risk established in the RA for the site minus the reduction achieved by natural processes and the EIPRS.

The no action alternative provides a relatively low degree of long-term effectiveness and permanence since, with exception of collected immiscible product, all contaminated residues will remain at the site untreated, and under partial control (i.e., restricted access due to current site fencing).

6.2.1.5 Overall Protection of Human Health and the Environment

Under this alternative, the overall protection of human health and the environment has been evaluated quantitatively through the RA which has been summarized in Section 1.5. This baseline risk assessment included both current and hypothetical future use scenarios. Risks to trespassers have been mitigated by the installation of fencing around affected areas of the site. Potential human health concerns were identified due primarily to the presence of DEHP in soil and DEHP, xylenes, and ethylbenzene in groundwater.

6.2.1.6 Reduction of Toxicity, Mobility and Volume of Contaminants

Under this alternative, the product recovery system provides for some contaminant reduction. The groundwater quality would be improved slowly by passive recovery. Contaminants in the groundwater and soil would naturally attenuate.

6.2.1.7 Implementability

This criterion is not applicable as no additional remedial actions will be implemented under this alternative.

6.2.1.8 Cost

The estimated cost for the no action alternative consists of:

- Groundwater monitoring costs.
- Skimmer O&M costs.
- Immiscible product disposal.

Table 6-1 provides a cost summary for Alternative 1. The estimated annual cost of this alternative is $79,000 per year. Using a present worth analysis at 5 percent compound interest over 30 years, the total present worth estimated cost of the no action alternative is $1,215,000.

6.2.2 Alternative 2: Institutional Controls

6.2.2.1 Description of Alternative

The institutional controls alternative involves implementation of the following actions:

- Property deed notation and land use restrictions.
- Groundwater restriction.
- An expanded groundwater monitoring program.
- Maintenance of existing site fencing.
- Continuation of passive immiscible product recovery.

Property deed notation involves annotating the site deed to alert prospective property buyers as to the presence of hazardous substances on site. These notations would be written to restrict future use of the property to nonresidential use. Groundwater restrictions involve designation of local groundwater sources as nonpotable with delineation of a corresponding well restriction area. Future site use restrictions may also be required based on human health risk considerations. Deed notation and land/groundwater use restrictions are also components of Alternatives 3 through 6. The restrictions would remain in place unless and until contaminant concentrations were sufficiently reduced to allow for unrestricted use of the property.

The expanded monitoring program calls for installation and quarterly monitoring of an intermediate depth well on Air Products property. Installation and sampling of a monitoring well at this depth and location will act as a sentinel well to monitor for the potential migration of dissolved contaminants onto the Air Products property under the Qal silt/clay unit. This well would be sampled quarterly for benzene, toluene, ethylbenzene and xylenes by EPA method 602. The results from these analyses would be submitted with NJDEPE documentation as part of the quarterly progress report.

6.2.2.2 Compliance with ARARs

The institutional controls alternative has the same deficiencies with ARARs compliance as the no action alternative.

6.2.2.3 Short-Term Effectiveness

Implementation of this alternative would not entail significant adverse human or environmental impacts. Therefore, Alternative 2 is judged to exceed this evaluation criterion. This judgment is based on the limited nature of the remedial action involved in implementing this alternative.

6.2.2.4 Long-Term Effectiveness and Permanence

Under the institutional controls alternative, current contamination would be left in place (with the exception of the removed immiscible product) and changes in contaminant levels would consist of those resulting from natural attenuation processes such as leaching, weathering, and biodegradation as well as from the product recovery system currently in place. Therefore, the residual risk under this alternative is essentially the baseline risk established in the RA for the site minus the reduction achieved by natural processes, the EIPRS, and assuring no contact with site soils and groundwater.

The institutional controls alternative provides a relatively low degree of long-term effectiveness and permanence since, with exception of collected immiscible product, all waste materials and associated contaminated media will remain at the site untreated and under partial control.

6.2.2.5 Overall Protection of Human Health and the Environment

By restricting access and groundwater usage at the site, Alternative 2 provides greater protection of human health and the environment than Alternative 1. Wader/swimmer and hypothetical future resident exposure scenarios would be eliminated as a result of the deed and well restrictions, as well as by maintenance of site fencing.

Fish caught in the Rockaway River adjacent to and immediately downstream of the L.E. Carpenter site may result in ingestion of fish exposed to some site related contaminants, although probably at lower intake rates than estimated in the RA. Surface runoff which may pick up surface soil from the site may discharge to the Rockaway River. However, most of the soil contaminants are located at depths of three feet or more (nearer the water table) and would not be transported in surface runoff. Under the remaining exposure scenario, future on-site worker contact with contaminated soil (e.g., during possible future regrading, construction, or excavation activities) would not be protective of human health. In addition, off-site migration of contaminated groundwater would not be mitigated under this alternative. Therefore, this alternative is judged as approaching but not completely meeting this evaluation criterion.

6.2.2.6 Reduction of Toxicity, Mobility, and Volume of Contaminants

Under this alternative, the product recovery system provides for some contaminant reduction. The groundwater quality would be improved slowly by passive remediation and natural attenuation.

6.2.2.7 Implementability

Since Alternative 2 involves institutional controls only, implementation would not present significant efforts. Therefore, Alternative 2 is judged as exceeding this evaluation criterion. It should be noted that this judgment is based strictly on the limited nature of action involved in implementing this alternative.

6.2.2.8 Cost

Table 6-2 provides a cost summary for Alternative 2. The total present worth estimated cost of the institutional controls alternative is $1,434,000.

6.2.3 <u>Alternative 3: Groundwater Treatment</u>

6.2.3.1 Description of Alternative

The groundwater treatment alternative involves the following remedial actions:

- Soil cover for DEHP contaminant soils.
- Spot excavation and disposal of surficial soils exceeding cleanup levels in locations other than east site soils (i.e., isolated hot spot soils).
- Active immiscible product recovery.
- Aboveground biological treatment and carbon polishing of groundwater.
- Recirculation of a portion of extracted groundwater within capture zone.
- Discharge of remaining extracted groundwater to deep aquifer zone.

DEHP contaminated surface soils would be covered with soil to mitigate the threat of direct contact, ingestion, inhalation, or erosion of soil contaminants. The primary applicability of a cover at the L.E. Carpenter site would be as a means of reducing potential contaminant migration via erosion of surface soils. A cover is particularly applicable in combination within situ bioremediation and/or groundwater extraction. These other treatment or removal technologies are most effective in the saturated zone, where, because of the immiscible product layer, the highest levels of contamination are present. These technologies would not be as effective at the surface layer or vadose zone where organic contaminant levels are lower.

The cover would be designed to allow infiltration into the vadose zone soils to allow natural attenuation of soil contaminants to continue. Contaminants leached from the soil would be collected by the groundwater extraction system.

The cover would be constructed as a 6-inch fill material overlay with a 6-inch layer of topsoil. Fill and topsoil has been selected over other cover materials because a high degree of impermeability is not desired. Vegetative cover would be developed to control erosion. Surface runoff controls, including grading and erosion control fences, are likely to be a component of any alternative involving a cover.

In areas without the soil cover, isolated hot spot surface soil excavation and disposal will be performed. These hot spot excavations are expected to be limited to minimal volumes of surface soils from various isolated locations containing lead and antimony in concentrations exceeding site specific cleanup goals, as well as some surficial soil located on Wharton Enterprises property which exceeds the NJDEPE cleanup goal for PCBs. Volumes of isolated hot spot soils utilized to estimate disposal costs were estimated by comparing concentrations detected in soil samples to concentrations of those contaminants in nearby soil samples. Depth of excavations were estimated at twice the depth of the sample to a maximum depth of the water table or a deeper uncontaminated sample.

The conceptual groundwater remedial strategy will be accomplished in two phases. Phase I provides for active recovery of floating product in advance of the startup of the aerobic biological groundwater treatment system. Extracted groundwater will be treated through the use of an oil/water/solids separator or clarifier prior to recirculation within the area of free product, above the clay layer. This recirculation will be utilized to create the hydraulic head necessary to optimize production recovery and ensure capture. Phase II will begin after recovery of floating product through operation of the Phase I system is no longer effective. Phase II provides for groundwater extraction and aboveground biological treatment. Phase II also provides for recirculation of a majority (estimated at 80 to 90%) of the extracted water within the capture zone and discharge of the remainder of extracted, treated water to the deep aquifer zone. The water being discharged to the deep aquifer will be polished by granular activated carbon after biological treatment to assure compliance with site specific discharge criteria.

To provide protection of human health and the environment by removing hazardous constituents from the subsurface, the following sequence of events would be initiated:

- Perform aquifer pumping test utilizing existing monitoring/recovery wells.

- Based on results of pumping tests and knowledge of contaminant concentrations, determine treatment process parameters, number, location, and depths of extraction wells and extraction rates.

- Use treatability studies to select the treatment system and to set operational parameters.

- Prepare and submit discharge approval application.

- Install the groundwater extraction and treatment systems (Phase I subsequently followed by Phase II).

- Actively operate groundwater extraction and treatment/discharge systems (Phase I subsequently followed by Phase II).

Expected contaminant concentrations in groundwater have been estimated (Subsection 5.3.2) based on previous monitoring data. While the weighted average calculation provides some indication of the initial concentrations under a given pumping rate, concentrations would vary significantly if the respective pumping rates in each recovery/extraction well are revised. Concentrations will decrease as the collection zone enlarges during extraction and as the aquifer becomes restored.

Aquifer pumping tests would be necessary for this and other alternatives that incorporate groundwater treatment. The aquifer pumping test should be conducted in at least two wells to provide a better estimate of initial contaminant concentrations during groundwater extraction as well as to refine the capture zone analysis. During the aquifer pumping tests the drawdown in surrounding monitoring wells will be measured to refine the locations of the proposed extraction points and the pumping rate of all skimming and extraction wells. This information would also be used to help select and design appropriate treatment technologies and select the final location of any required extraction wells. For example, high concentrations of organics are more effectively treated using biological treatment, while low concentrations are better treated using carbon adsorption. Treatability studies can be used to identify treatment system design parameters. For estimating and comparative purposes, biological treatment is presented as the primary groundwater treatment technology. Preliminary results of the Treatability Study performed to evaluate aerobic biodegradation for this Feasibility Study indicate that the indigenous bacteria are capable of metabolizing the primary contaminants of concern in groundwater, namely DEHP, xylenes, and ethylbenzene.

A typical biological treatment schematic is presented in Figure 6-1. Significant features of the system include equalization/nutrient mix tank (optional, based on influent conditions), the bioreactor vessel, effluent "polishing" treatment, and vapor phase granular activated carbon (GAC) treatment for volatile organics stripped during aeration in the bioreactor or during storage in the equalization tank. The fixed film submerged aerobic bioreactor was selected (for costing purposes) based on the low organics loading rate expected. This type of reactor, if designed for a 80 gpm flow, would consist of a structured plastic media in a reactor with approximate dimensions of 24 ft long, 12 ft wide and 9 ft high. This system was sized based on expected influent concentrations over the life of the system's operation. During startup of Phase II, the flow will be regulated to avoid mass-loading at quantities higher than can be effectively treated by the system. As dissolved product concentrations within the influent decrease over time, the flow will be increased until the optimal mass-loading conditions are met. For costing purposes it was assumed that a 32-ft by 24-ft building was required to house the system components.

After a period of operation, concentrations of organic compounds are likely to be reduced to the point where they cannot sustain an active microbial population but are still above cleanup goals. At that point, the groundwater treatment system can be converted to carbon adsorption (which is already on-line as a polishing step). Carbon adsorption is effective for the site contaminants at low concentrations and has been used for costing this alternative. Other unit processes or technologies may be effective and will be evaluated during the Remedial Design. For estimating purposes, biological treatment is estimated to operate for 10 years, followed by 20 years of carbon adsorption treatment. Other alternatives to GAC for polishing will be considered during the Remedial Design.

Process variations, which could be evaluated following the aquifer pumping test include fluidized bed and fixed film/carbon adsorption bioreactors. These bioreactors are able to operate with relatively low levels of biomass unlike activated sludge processes which typically involve the use of a post-treatment clarifier and periodic sludge disposal. At the anticipated organics loading rates, biomass generation and discharge would likely be low enough so that a sand filter would provide sufficient biomass removal capacity. However, should biomass generation be higher than expected, the clarifier utilized to pretreat the raw water influent may be relocated to filter the bioreactor effluent prior to sand filtration.

Another process variation combines both biological treatment and carbon adsorption, for example, the PACT[R] system marketed by Zimpro/Passavant, Inc. These systems add powdered activated carbon directly to the biological treatment step. In such an approach the contaminants are captured by the carbon slurry which effectively increases the amount of time the groundwater contaminants are in contact with both the carbon and the biological mass. Treatment occurs over the full solids residence time as opposed to only the hydraulic residence time. Another potential benefit of these systems is that fewer volatile emissions would be generated by the aeration of the bioreactor. The powdered carbon reduces the effective volatility of the influent stream which makes more organics available to sustain the biological treatment. The use of powdered carbon, which is less expensive than granular carbon, also buffers the biological processes from shock loading. The primary determinant of the applicability of a combination of biological and carbon adsorption treatment is the groundwater organics loading, which will be known with a higher degree of certainty after the aquifer pumping test.

The groundwater treatment system which has been conceptualized does not include an operable unit specifically designed for removal of metals (limited metals uptake by microorganisms and subsequent concentrations within the biomass has been documented in prior biological treatment systems). Since preliminary calculations indicate that metals concentrations in the treatment influent stream are below discharge criteria, addition of a metals removal operation was not deemed necessary.

6.2.3.2 Compliance with ARARs

It is anticipated that the discharge from the groundwater treatment system can meet chemical-specific and action-specific ARARs established under the NJPDES program. If isolated hot spot soils are contaminated with organics (such as DEHP or xylenes) at concentrations that exceed LDRs, or exceed TCLP criteria for metals or organics, these materials will need to be treated to comply with RCRA prior to off-site disposal. Disposal of any soils excavated during installation of monitoring wells may also require treatment to comply with RCRA. Air emissions will be treated, if necessary, in order to comply with relevant and appropriate regulations such as N.J.A.C. 7:27-16 and -17.

6.2.3.3 Short-Term Effectiveness

During implementation of Alternative 3, identified areas of concern include:

- Fugitive Air Emissions - Groundwater treatment operations could result in air emissions of volatile organics from the bioreactor and accumulation tank. Emissions from these operations would be treated by vapor-phase carbon adsorption.

- Well Installation - Drilling or excavation activities could result in the exposure of workers involved in remediation to airborne dusts and vapors. Inhalation, ingestion, and dermal contact with contaminated media must be prevented by utilization of appropriate protective clothing and equipment during site remedial activities. Utilization of the existing network of monitoring wells will also minimize exposure to contaminated media.

- Cover Installation - Some particulate emissions during cover installation is anticipated, however, dust control methods should reduce this risk. Furthermore, most of the soil contamination is in the subsurface.

6.2.3.4 Long-Term Effectiveness and Permanence

For Alternative 3, the majority of site soils are left in place. With the soils as a potential long-term contamination source, the time for groundwater treatment is extended. Soils in specific areas described in Section 6.2.3.1 not being covered and containing antimony, lead, and PCBs in concentrations greater than cleanup goals would be excavated and shipped for off-site disposal in accordance with waste characterization. For costing purposes, the treatment option utilized for off-site disposal of isolated hot spot soils is incineration, with subsequent fixation of metals in the ash, if required. Further, for costing purposes, a PCB action level in soil of 2 mg/kg (the nonresidential surface soil cleanup goal) was utilized. If a deed restriction cannot be placed on Wharton Enterprises soils which contain PCBs at concentrations above action levels, a cleanup goal of 0.49 mg/kg in surface soil will be applied.

The potential for contaminant migration via erosion of DEHP contaminated soils would be mitigated by the installation of a vegetative cover in this area. Alternative 3 would effectively contain and control groundwater contamination.

6.2.3.5 Overall Protection of Human Health and the Environment

Implementation of this alternative would be protective of human health. The exposure pathways identified in the RA would be eliminated or mitigated.

6.2.3.6 Reduction of Toxicity, Mobility, and Volume of Contaminants

Alternative 3 satisfies the statutory preference for treatment as a principal element of the alternative. For the primary contaminants of concern (DEHP, xylene, and ethylbenzene), typical expected removal efficiencies for aerobic biological treatment followed by carbon adsorption would be greater than 99%.

Contaminants removed in the biological treatment unit would be microbially metabolized and destroyed. Generation of sludge requiring disposal is expected to be minimal, due to the low organic levels in groundwater.

Excavation of hot spot soils contaminated with antimony, lead and PCBs would permanently reduce the mobility of contaminants. The ultimate treatment/disposal method applied to soils excavated from isolated hot spots would be in accordance with the results of waste characterization analyses. Incineration of hot spot soils would permanently destroy the organic constituent in the excavated soils. Fixation of residual metals in the resultant ash would reduce the mobility of these toxic constituents. If soil hot spots containing lead or antimony are not contaminated with organics, fixation of the metals in soil would be implemented without incineration. An impermeable cap would decrease potential contact with and leaching of heavy metals in surface soil hot spots.

By treating the groundwater, the quantity of contaminants in the water will be reduced; therefore, concentrations in the groundwater will also be reduced. The volume of contaminants remaining in the treated groundwater, after a carbon adsorption polishing step, is expected to meet NJPDES standards.

6.2.3.7 Implementability

Alternative 3 involves installation of groundwater extraction and recirculation/discharge wells, a groundwater collection/piping system, sump tanks, oil/water separator (clarifier) bioreactor unit, carbon adsorption units, and associated piping and instrumentation. Construction of these components can be accomplished by using common construction techniques.

Groundwater collection, by the use of pumping recovery wells is a proven technology for extracting groundwater for further treatment. Migration of contaminants present in the shallow groundwater below the site will be contained. Active recovery could be achieved rather easily when the groundwater treatment system is on-line. Drawdown should be limited, however, to prevent contamination of deeper soils with a free product layer which would float on the depressed water table. By utilizing the optimal number of closely spaced wells which would pump at low rates, shallow drawdown profile could be assured and contamination of deeper soils by floating product could be minimized.

The proposed groundwater treatment technologies are well established and commercially available as standard equipment. The application of these technologies, particularly biological treatment, would require development through further treatability/pilot studies to establish process parameters.

Additional treatment units, such as membrane separation, sand filtration and metals treatment units, could be added in a modular fashion as required to meet chemical-specific ARARs. All the units of the treatment system are transportable to the site and can be installed easily. In addition, various controls will have to be installed to monitor the process.

Operation of the treatment unit would be continuous as will be groundwater recovery. Spent carbon in the carbon adsorption units will be replaced when exhaustion occurs. The spent carbon will be transported to an approved regeneration facility where the contaminants will be separated from the activated carbon and will then be incinerated.

It is expected that concentrations of contaminants in the shallow water zone would significantly decline and continue to do so over an extended period of time. In order to track the decrease in organic concentrations, a groundwater monitoring program would be implemented. The analytical methodologies utilized during the initial phases of remediation (600 series) would be upgraded to more sensitive drinking water methodologies (500 series) as contaminant concentrations decreased in the shallow zone in response to the remedial actions.

This alternative also involves the excavation and shipping for treatment/disposal of a limited amount of surficial soils, as well as the placement of a permeable soil and vegetative cover on a selected area of site soils. These processes can be implemented with standard, commercially available earthmoving equipment and construction techniques.

In order to implement this alternative, construction, installation, and operating permits are required for all units comprising the treatment system. Discharge of the final treated water to the deep aquifer zone will require a compliance with the NJPDES permitting process. The process of obtaining approval to discharge to groundwater can occupy several months.

6.2.3.8 Cost

The capital cost items identified for Alternative 3 include:

- Deed notation and land/groundwater use restrictions.

- Additional groundwater monitoring well.
- The product extraction technique conceptualized for Phase I consists of three shallow, large diameter caissons and one extraction well. Recirculation of extracted groundwater will be accomplished via four wells.
- The groundwater extraction technique conceptualized for Phase II consists of six extraction wells. Recirculation of approximately 80 to 90% of extracted water will be accomplished via five recharge wells. Discharge of the remaining water will be accomplished through one deep groundwater discharge well. Discharge criteria compliance monitoring will be limited to the L.E. Carpenter constituents of concern as specified in Table 2-2.
- Treatability testing (including pump test and field parameter optimization).
- Permitting fees for groundwater/air discharge
- Groundwater treatment system, utilizing a fixed film bioreactor as the primary treatment unit.
- Soil cover for contiguous DEHP contaminated soils.
- Hot spot soil excavation, including confirmatory post excavation sampling of four samples in each isolated excavation, and backfill of hole.
- Hot spot soil transportation and off-site treatment/disposal, including waste characterization analysis. Ultimate treatment/disposal of isolated excavated materials will be performed in accordance with the results of waste characterization analyses. Possible treatment and disposal options may include capping, fixation, off-site disposal as ID-27 material, and incineration. Incineration costs were utilized for estimation purposes.

Table 6-3 provides a cost summary of Alternative 3. The biological groundwater treatment system cost utilizes a fixed filter bioreactor system. Using a present worth analysis at 5 percent compound interest over 30 years, the total present worth estimated cost of Alternative 3 is $8,944,000.

6.2.4 Groundwater Treatment with Reinfiltration

6.2.4.1 Description of Alternative

Alternative 4 consists of extraction of the contaminated groundwater plume, aboveground enhanced biological treatment of the extracted groundwater and recharge of the groundwater to the subsurface. A portion of the groundwater will be reinfiltrated to the shallow aquifer zone to allow for flushing and stimulation of natural biological degradation within the contaminated soil zone. The area of recharge will be designated as a CAMU.

Data generated during the well point and gamma-logging investigations indicate the widespread presence of a relatively continuous shallow clay layer which is undulatory and acts to trap the majority of the immiscible product and contaminated groundwater in a topographic depression of the clay. Further, the presence of this clay forms a natural low permeability soil zone which can be used to define the treatment basin which will be utilized to recycle extracted, amended groundwater with the purpose of flushing product contaminated soils and stimulating the natural biological degradation of those contaminants by the indigenous microfauna. This treatment basin can and will meet the definition of a CAMU and as such will be used to consolidate and treat organic contaminated soils.

The conceptual remedial strategy for Alternative 4 will be accomplished in two phases. Phase I incorporates active recovery of floating product in advance of the groundwater treatment system startup. Phase II will commence when the recovery of floating product through the active system is no longer efficient. Phase II will incorporate the extraction of groundwater from pumping wells, aboveground treatment, and discharge of treated groundwater by several methods. During Phase II a portion of the extracted water will be recycled within the CAMU for the purpose of flushing and stimulating biological activity of the soils. A portion of the groundwater will be recirculated within the capture zone in order to create the hydraulic gradients necessary to assure capture. The small portion of treated effluent will be discharged to a deeper portion of the aquifer, after being treated to meet the site-specific discharge criteria. It is important to note because recycled and recirculated water will remain within either the CAMU or area of capture, compliance with the site-specific discharge criteria will not be required. The two phases are described in more detail below.

Phase I:

Phase I has been designed to remove floating product by active depression of the groundwater table. Water table depression has been designed to optimize product recovery while reducing the cone of depression of product which could create a significant "smear zone" resulting from contact between floating product and deeper, formerly clean, soils.

In order to accomplish this, four shallow recovery wells are proposed. Figure 6-2 presents the approximate location of recovery and recharge wells conceptually specified for Phase I. Three of the four wells will be large diameter caisson wells approximately 10 to 12 feet deep and located within the CAMU. The fourth recovery well will be an eight-inch pumping well approximately 15 to 17 feet deep and located in the vicinity of monitoring well MW-1 and well point WP-A4. The extracted water from all wells will be treated with an oil/water/solids separator and recirculated within the capture area through gravity feed to four large diameter caisson recharge wells. Discharge criteria would not apply to the recirculated water as the water is contained within the area of capture and will be further treated during Phase II remedial activities.

Phase II:

Phase II will be implemented following completion of active recovery of the floating product plume (Phase I). This phase of the remediation has been conceptually designed to extract groundwater from the shallow and upper intermediate aquifer through a series of six eight-inch recovery wells drilled to a depth of approximately 30 feet. Figure 6-3 presents the approximate location of recovery and recharge wells conceptually specified for Phase II. This water will be treated in an aboveground biological reactor as specified for Alternative 3 prior to disposition.

Three distinct areas of recharge have been defined for the treated effluent stream. A portion of the water will be recycled through infiltration in the CAMU. Class II-A groundwater discharge criteria will not be applicable to the recycled portion of the groundwater as all the water will be captured within the CAMU. The majority of the water will be recirculated within the capture zone. This water will be recirculated through a series of five wells drilled to approximately 30 foot depth. Since this water will remain within the Capture Zone, Class II-A groundwater discharge criteria will not be applicable. The remaining water will be discharged to a deeper portion of the aquifer via gravity feed flow through an eight-inch well drilled to a depth estimated to be 60 to 100 feet. As this portion of the treated groundwater effluent is being discharged to an area outside the capture zone(s) created during the extraction and recharge of groundwater, Class II-A groundwater quality criteria for the criteria of concern (as specified in Table 2-2) are applicable to this effluent stream as monitored at the central discharge point.

The Phase I recovery system will be operated as passive skimming wells during Phase II. As a result of the groundwater table depression, it is likely that a small volume of product which is adsorbed onto soil particles with the highest elevations within the "smear zone" will desorb and become free-phase product. This product will then flow along the cone of depression towards the active pumping wells. A portion of this product will be intercepted by the large diameter caisson recovery wells and will be skimmed off for collection and disposal.

Since the rate of naturally occurring in situ biodegradation may be limited by a lack of oxygen and nutrients, addition of these substances will enhance the process and reduce the time frame required to remediate the affected groundwater. If the rate of treatment is limited by the rate of mobilization of DEHP from soils, surfactant addition may be considered. Additionally, by allowing the treated, amended groundwater to trickle through the vadose zone, the potential for contaminant/moisture contact within the soil pores increases, thereby stimulating microbial degradation of contaminants sorbed to soil particles within the vadose zone. The groundwater infiltration system, located in the CAMU, would be covered with a soil and vegetative cover to protect it from potential damage. The primary purpose of the cover would be to reduce the potential for contaminant migration via surface runoff, while allowing additional infiltration from precipitation. As with Alternative 3, Groundwater Treatment, spot excavation and disposal of isolated soils located outside the treatment zone would be performed. Additionally, excavation and disposal of the waste contained in the disposal area, discovered during the enhancement of the product recovery system, would be performed as this waste stream is dissimilar to the bulk of contaminated soils and may prove inhibitory to in situ treatment.

Technical issues to be addressed in developing this alternative include the following:

1) Establishment and maintenance of hydraulic control to ensure capture of mobilized contaminants.
2) Determination of the extent to which treated groundwater can be reinfiltrated.

3) The biodegradability, toxicity (if any), cost, and need for surfactants.

It is difficult to predict the length of the remedial period required to adequately flush and treat all contaminated areas on the site. As with most in situ treatment options, the limiting factor is likely to be the ability to move (both during extraction and reinfiltration) water through all contaminated areas. To the extent that reinfiltration of groundwater containing nutrients, oxygen and microbes enhance in-situ biological activity, the length of the remedial period may be reduced.

Laboratory scale treatability studies were conducted to assess the feasibility of bioremediation of soils at the L.E. Carpenter site. These studies examined the biodegradability of site contaminants in groundwater and the potential for flushing contaminants from site soil using both water and surfactant solutions. Results from these studies are presented in the Bioremediation and Soil Flushing Treatability Study Report, L.E. Carpenter and Company (IT Corporation, 1992). The results from these studies indicate that a combination of soil flushing and bioremediation is technically feasible for soils at the site. Major findings in support of this conclusion include the following:

1) Contaminants of concern in site groundwater are biodegradable. Indigenous microorganisms in site soils have the capability of degrading site contaminants and external seed sources are not necessary. Nutrient amendment would be necessary. DEHP half-lives in amended site groundwater are on the order of 60 to 70 hours. Removal of volatile contaminants occurs through a combination of volatilization and biodegradation.

2) Phthalate contaminants are not rapidly mobilized from soils by simple aqueous flushing. The addition of surfactants can enhance the rate of removal of phthalates from soils and would need further evaluation as part of the Remedial Design. Relatively high surfactant concentrations may be necessary.

3) Based upon these preliminary data, remedial criteria for phthalates in soils may be achievable by surfactant and flushing. The flushing test simulated a ten year flushing operation (on the basis of pore volumes of water circulated).

As a result of these treatability studies, the bioremediation alternative for the L.E. Carpenter site would likely entail the following components:

- Property deed notation and land use restrictions.

- Floating product/groundwater extraction system installation and operation. As described in the discussion of Alternative 3, a phased approach to groundwater extraction would be utilized. Phase I would incorporate active recovery of floating product in advance of full operation of the groundwater treatment system. All extracted, treated groundwater would be recirculated within the capture zone. Phase II would incorporate extraction of groundwater, treatment and disposition to three distinct areas. Pretreatment groundwater would be recycled within the CAMU to flush the soils and stimulate biological activity. The majority of water would be treated and recirculated within the capture zone to create the hydraulic gradients necessary to ensure capture. The remaining water would be treated to comply with site specific discharge criteria and discharge to the deeper aquifer zone. For costing purposes, four extraction and four discharge points were conceptualized for the Phase I system. The Phase II system was costed utilizing five extraction points, one infiltration bed approximately 50,000 ft^2 for water recycling within the CAMU, six intermediate-depth wells for water recirculation and one deep well for water discharge. Ultimate determination of the number, placement and pumping rates of extraction wells and recharge points will be determined during Remedial Design.

- Remedial Design treatability study to determine effectiveness and optimize system parameters for aboveground groundwater biological treatment and polishing (carbon adsorption).

- Remediation via biological treatment of extracted groundwater. The treatment system would most likely consist of an aerobic fixed film submerged bioreactor, utilizing naturally occurring microorganisms. The system may also include GAC treatment for organic constituents in the vapor phase from the equalization tank vent. The treatment system is expected to be converted to carbon adsorption (or other polishing technology) as contaminant concentrations diminish.

- Excavation and consolidation of DEHP contaminated soils. Since these soils are being consolidated within the CAMU for purposes of applying in situ treatment, this does not constitute placement, and LDRs do not apply.

- Reinfiltration of some treated groundwater (to maximum amount possible) with added oxygen (as hydrogen peroxide) and nutrients during Phase II. Surfactant addition may also be necessary depending upon reaction rates. The reinfiltration system will be constructed of perforated piping to allow treated water to percolate at a slow rate through the unsaturated zone soils within the CAMU. The reinfiltration network will be designed to distribute the maximum amount of treated water possible, given site hydraulics, with its burden of oxygen, nutrients, and microorganisms over the treatment zone. A larger portion of the treated water will be recirculated within the capture zone. The remaining water will be discharged to the deeper aquifer zones in accordance with a NJPDES DGW permit. Discharge criteria for those constituents of concern were specified in Table 2-2.

- Provide a 12-inch soil cover for the area of groundwater infiltration system. This cover would serve a dual purpose: to limit potential contaminant migration due to erosion and surface runoff of consolidated soils being treated; and to protect the infiltration piping from damage and reduce the potential for freezing. Surface runoff controls would also aid in controlling erosion.

* Long-term (20 year) groundwater monitoring associated with continuing groundwater treatment/containment. The monitoring schedule is a conservative estimate of the period required to fully remediate the groundwater and may be revised based on treatability studies and actual site conditions. Analytical methodologies utilized are to be consistent with the mass loading of contaminants in the groundwater. During the initial phases of remediation, 600 series organic methodologies will be utilized. As remediation progresses, 500 series (drinking water) methodologies will be utilized to detect the decreasing concentrations of organic constituents in the groundwater.

* Spot excavation and disposal of soils containing PCBs, lead, and antimony at concentrations exceeding cleanup levels in locations other than east site soils. Disposal will be in accordance with the results of characterization sampling performed on excavated materials. Possible treatment/disposal options may include capping, fixation, off-site disposal as ID-27 waste, and incineration. For costing purposes, a PCB action level of 2 mg/kg in soils was assumed. Should deed restriction of affected soils not be possible, a cleanup goal of 0.45 mg/kg in surface soils will be applied.

* Excavation and disposal of disposal area sludge/fill, which may prove inhibitory to in situ treatment.

Alternative 4 differs from Alternative 3 in that a portion of treated groundwater will be percolated to the subsurface (via the CAMU). This portion of extracted water will not be passed through activated carbon as a polishing step prior to being percolated to the subsurface. This allows residual organic substrate and microorganisms to enter the subsurface along with the added nutrients and oxygen source and facilitate some in situ bioremediation. Proper design of the extraction and reinfiltration system would assure total containment of any groundwater plume. Alternative 4 may also differ from Alternative 3 in the use of surfactant to mobilize soil contaminants (DEHP) and thus increase their biological availability, based on the outcome of Remedial Design. This may reduce the length of the remedial period. At the same time the increased influent concentration will increase the loading to the bioreactor and possibly affect the configuration of the treatment components.

It should be noted that Alternative 4 could be implemented without surfactant addition. This could substantially reduce the rate of mobilization of DEHP from soils and extend the remedial period. Selection of surfactant, if any, and optimization of feed rate would be determined during Remedial Design. Use of surfactant is subject to further treatability testing and cost/benefit analysis. Further, if surfactant use is applied, the Remedial Design must assure that its addition will not cause uncontrolled movement of contaminants either vertically or beyond the capture zone.

Similar to Alternative 3, the organics loading in the extracted groundwater will eventually diminish to the level where it could no longer sustain an active microbial population. At that point the groundwater treatment system can be converted to carbon adsorption. For estimating purposes, biological treatment is estimated to operate for 6 years, followed by 14 years of carbon adsorption treatment. The capital cost of the carbon adsorption units is included in the original treatment system capital cost.

Biodegradation has the potential to fully degrade the organic contaminants contained in the groundwater. Biodegradation is a proven treatment for gasoline constituents (including ethylbenzene and xylenes). Site specific treatability studies have proven that biodegradation by indigenous microorganisms is also a viable treatment option for DEHP.

By destroying contaminants currently sorbed within the soil matrix, in situ treatment potentially reduces the opportunity for recontamination of the treated aquifer. Microbial degradation occurs at the contaminant/moisture interface. The groundwater/peroxide/nutrient infiltration system can be designed to allow the oxygen and nutrients in the water to percolate through the contaminated subsurface vadose zone soils. This system would allow contact between the contaminants within the soil matrix and the treated water, and thereby may increase the rate of microbial degradation of those contaminants.

In addition to reducing the time frame required for remediation of contaminated groundwater, a major advantage of implementing an in situ remedial technology is that a large volume of soils are not excavated. At the L.E. Carpenter site, surficial soils are generally not contaminated above the proposed cleanup goals. The act of removing the surficial soils and exposing the contaminated subsurface soils would increase the likelihood of direct contact, incidental ingestion and inhalation of volatile and semivolatile organic compounds contained within the subsurface soils and the shallow groundwater. The large volume of soils which would need to be excavated for an ex-situ process is another factor which makes in situ treatment favorable, as well as the potential need to dewater saturated excavated soils prior to treatment in an ex-situ treatment system, such as incineration. Further, any soils which must be excavated to implement remedial action (i.e., trenching operations) can be consolidated to within the area of soils treatment through infiltration of amended groundwater.

The major technologies implemented for this alternative are similar to those described for Alternative 3, with the addition of the piping/infiltration system to be used to introduce the oxygen, nutrient, and, possibly surfactant-amended water through the vadose zone soils to the water table. The final system design will depend on flow rates and hydraulic residence times as determined by treatability testing and site specific data gathered during aquifer testing. Conceptually, the system will be constructed of perforated or porous piping laid out in a series of mains and laterals, which would be able to distribute the treated, amended groundwater to the subsurface over a large area. The areal extent and nominal piping size will be determined during Remedial Design. Further, the volume of water which can be infiltrated through the vadose zone will also be determined during Remedial Design. The groundwater which was extracted and treated, but not recycled or recirculated will be discharged to the deeper aquifer zone in accordance with the requirements of a NJPDES DGW permit. The recycled and recirculated volumes must be designed to allow hydraulic containment of the groundwater within the capture zone by the operation of groundwater extraction wells. Containing the water within the capture zones serve two purposes: it reduces the possibility of negative impacts due to migration of nutrients off site, and it concentrates available oxygen and nutrients, and, therefore, microbial activity, to within the area of concern. Soils contaminated with DEHP at concentrations above cleanup goals which are not located within this treatment area (i.e., soils associated with the former underground storage tanks E5 and E8) will be excavated and consolidated within the CAMU.

As with Alternative 3, spot excavation of soils containing contaminants at concentrations above cleanup goals outside of the treatment zone would reduce the risks associated with them. Additional spot excavation within the CAMU could be used to remove specific isolated volumes of materials with contaminant loadings which may inhibit the biological treatment process due to the inherent toxicity of the constituents to the native microorganisms. Specifically, areas of elevated metals and PCB concentrations, as well as the waste observed in the disposal area will be addressed.

6.2.4.2 Compliance with ARARs

Implementation of Alternative 4 is anticipated to result in compliance with all chemical action and location-specific ARARs, specifically;

- Extraction and enhanced biological treatment of groundwater is expected to meet NJPDES requirements, as well as site specific groundwater cleanup goals, prior to discharge to the deeper aquifer zone. Higher concentrations are likely in water being recycled and recirculated during the early stages of the remedial action. Since these effluents streams will be contained within the groundwater collection zone, discharge criteria will not apply. Addition of nutrients and oxygen will stimulate microbial action naturally occurring in situ, thereby reducing the time frame required for remediation of aquifer and isolated, affected soils.

- The nonintrusive nature of this alternative would limit potential negative impacts to wetlands, including increased siltation and sediment loading to the Rockaway River, which could impact downstream wetlands. Wetlands mitigation, as specified in N.J.A.C. 7:7A-14, would be performed to alleviate any potential minor impacts to wetlands resulting from remedial activities.

- Operation of the CAMU will allow for consolidation of organic contaminated soils for soils treatment and active recovery of product and contaminated groundwater. The LDRs under RCRA will not be applicable to soils placed within the CAMU.

- Off site regeneration or disposal of spent granular activated carbon potentially used for vapor control during enhanced biological treatment and for treatment of groundwater in later years, as well as off site disposal of the floating product recovered via operation of the floating product recovery system, and treatment/disposal of isolated hot spot soils, will meet all applicable RCRA (and potentially TSCA) treatment and disposal criteria.

* Closure and post-closure care requirements will be met by implementation of in situ treatment.

* Location specific ARARs concerning flood plain management and operation of a RCRA facility within a 100-year and 500-year flood plain will be met.

6.2.4.3 Short-Term Effectiveness

The nonintrusive nature of this alternative is conducive to minimizing short-term impacts. However, limited excavation during the placement of the infiltration system will be necessary, as well as excavation of "hot-spot" soils. Additionally, implementation of Option B would require excavation and subsequent consolidation of soils prior to installation of the collection trench. Engineering controls (e.g., dust and runoff controls) during implementation would be used to control short-term impacts. While surfactant addition (if used) and microbial activity may mobilize sorbed contaminants, they will be collected by the groundwater extraction system.

6.2.4.4 Long-Term Effectiveness and Permanence

Two major factors must be considered in evaluating Alternative 4: the biodegradability of the contaminants in the soil matrices and the site-specific transport conditions as determined by the hydrogeology.

The organic waste constituents in groundwater at the L.E. Carpenter site are generally biodegradable under appropriate conditions. The rate and effectiveness of biological treatment of soils may be affected by the elevated contaminant concentrations present in the groundwater and immiscible product plumes as well as the ability to deliver nutrient and oxygen to the sorbed compounds. Some degradable contaminants may prove toxic or inhibitory to microorganisms at sufficiently high concentrations. When contaminants are present as free phase or as large aggregates, microbial activity, which occurs at the contaminant-water interface, may be limited by the surface area of the waste material itself. These factors may limit the rate or extent of biological treatment achievable. In addition, the degradation of complex organics (such as DEHP) may be limited by their aqueous solubility and/or their adsorption to soils. The low solubility of DEHP may be a potential constraint in the overall rate of soil treatment under this alternative. These factors may prove most significant in attempts at in situ soils treatment.

The success of this approach would depend upon the physical and hydrogeological characteristics of the zone to be remediated. In general, in situ approaches are primarily applicable where the subsurface conditions are amenable to the controlled flushing of the contaminated zone with the treatment solution. Site specific treatability testing indicates the soils would be amenable to flushing and adequate distribution of oxygen and nutrients via reinfiltrated groundwater. However, the large number of boulders and the heterogenous composition of the soil fill material may result in localized areas of poor circulation.

In as much as in situ treatment degrades and detoxifies the waste constituents, this alternative would provide a relatively high degree of long-term effectiveness, and would constitute a permanent solution. It is possible that a diminishing level of residual microbial activity would persist following the actual remedial action. As long as residual nutrients (particularly added nitrogen) are recovered from the contaminated zone, the materials remaining in the soil after remediation would not have a negative impact upon the groundwater or other environmental media.

6.2.4.5 Overall Protection of Human Health and the Environment

In situ treatment offers the potential for degradation and detoxification of contaminants, providing a long-term and permanent solution without the need for extensive excavation. A major advantage of enhancing the natural in situ biodegradation of contaminants is that it may effectively treat soil contaminants present below the uppermost portion of the groundwater zone. Treatment of soil contaminants present at depth would improve the groundwater quality at the site and would decrease the time required to achieve the remediation objectives.

6.2.4.6 Reduction of Toxicity, Mobility, and Volume of Contaminants

Both options of Alternative 4 satisfy the statutory preference for treatment as a principal element of the alternative. As discussed previously, this alternative would degrade some wastes completely, and most residuals remaining from incomplete degradation would generally be of low toxicity. Surfactant addition, microbial activity and the increased rate of groundwater flow through the treatment zone may mobilize sorbed contaminants. In fact, mobilization of sorbed contaminants is a significant step in the biodegradative process. Bioremediation generates little waste for off site disposal. Generation of sludge in the bioreactor is expected to be moderate.

6.2.4.7 Implementability

Implementability of Alternative 4 would roughly match Alternative 3, with the addition of the groundwater infiltration system. Considerations in implementing this alternative are:

- The ability to reinfiltrate sufficient treated groundwater.
- The reactivity of adsorbed contaminants.
- Construction of the infiltration system.

The ability to reinfiltrate treated water is dependent upon site hydraulics. The rate of infiltration, based on slug tests, will probably be lower than optimum. The rate of infiltration of treated water through shallow site soils will be further determined during Remedial Design. The reinfiltrated water will be amended with nutrients and oxygen to stimulate biological activity within the CAMU. It is important to optimize the infiltration rate to achieve maximum microbial activity. This will establish the timeframe and economic viability of the infiltration treatment.

Another consideration in determining the implementability of this alternative is the reactivity of adsorbed contaminants. Biological degradation of chemical species is generally limited to the chemical-water interface. This limitation, therefore, requires the contaminant to be accessible to an aqueous media, either as a dissolved constituent of water or in a saturated solid media. Should limitations of infiltration rate limit continual wetting of vadose zone soils (simulating saturated conditions), then the rate of site remediation will be limited by the ability and rate of sorbed contaminants to be flushed into the aqueous phase.

The physical infiltration system (i.e., piping and pumping) is a standard, readily available, and widely accepted technology. Construction and operation of this system should be straightforward and easily implemented.

6.2.4.8 Cost

The capital cost items identified for Alternative 4 include:

- Essentially all cost items required in Alternative 3.
- Excavation and consolidation costs to allow for treatment of DEHP contaminated soils which originally are not within CAMU.
- Excavation and treatment costs for disposal area wastes.
- Hydrogen peroxide/nutrient/surfactant addition system.
- Installation of piping and pumps for the infiltration system.

It should be noted that, as in Alternative 3, while cost estimates for disposal/treatment of excavated hot spot soils utilized incineration with subsequent fixation of metals in the incinerator ash as the treatment method, actual disposal/treatment methods applied to these wastes will be consistent with the characterization analyses performed on the excavated soils. Possible treatment/disposal options include capping, fixation, and removal off site as ID-27 material. Excavation costs include confirmatory post excavation sampling at a frequency of four per "hot spot". Actual disposal area waste confirmatory sampling locations will be based on field screening performed with an organic vapor monitor and is estimated to be six samples. Transportation and disposal costs include the cost for waste characterization analyses, performed at the frequency recommended by NJDEPE Bureau of Waste Classification.

Operation and maintenance costs for this alternative include groundwater treatment and immiscible product removal items specific to Alternative 3 as well as items specific to the in situ treatment (hydrogen peroxide, groundwater reinfiltration, and quarterly soil sampling and analysis to measure the treatment effectiveness). It is assumed for costing purposes that groundwater analyses performed at the beginning of the remediation is 600 series, switching to 500 series when the concentration of contaminants in the aquifer approach cleanup levels and a lower detection limit is required to determine compliance with remedial goals. Discharge compliance monitoring costs were calculated based on monthly analysis for those constituents of concern as specified in Table 2-2.

Table 6-4 provides a cost summary for Alternative 4. Using a present worth analysis at 5% compound interest over 20 years, the total present worth estimated cost of Alternative 4 is $11,028,000.

6.2.5 Alternative 5: Excavation/On-Site Soil Washing/Bioslurry Treatment

6.2.5.1 Description of Alternative

Alternative 5 consists of excavation of contaminated soil, on-site soil washing of excavated soils, and placement of the cleaned coarse fraction back on site. The fine fraction will be treated in a bioslurry reactor to destroy the organic contaminants based upon the results of a treatability study. The scrubbing action of the soil washing technology should remove any leachable metals contained in the soils. Process washwater will be treated prior to recycle in the soil washer. This process will apply to all contaminated soils above the health-based action levels. In addition, all the unit processes described in Alternative 3, Groundwater Treatment, will apply. These measures will be implemented to assure long-term groundwater containment.

The major components of this alternative include:

- Operation of a product recovery system (Phase I) to remediate floating product layer located under the eastern portion of the site which is a continuing cause of groundwater and subsurface soils contamination. The skimmer system would operate until the floating layer diminishes to the point where it is no longer feasible to continue operation.

- Implementation of a groundwater containment (extraction and treatment) system to eliminate potential off-site migration of contaminated plume which could adversely affect the groundwater quality of the area.

- Cap and pave northern portion of site located west of the railroad right-of-way to provide a location for on-site treatment equipment and materials staging.

- Treatability study to optimize system parameters for soil washing and soil bioslurry treatment.

- Excavation of contaminated soils and isolated hot spot soils (to a maximum depth of 1 ft below lowest observed water table) to the soil cleanup standards. Immiscible product on groundwater will be skimmed off and disposed of off site.

- Excavation and disposal/treatment of the disposal area waste. This waste stream would be segregated from the bulk of the excavated soils during the excavation process. Off-site incineration would effectively treat the organic constituents in this waste, while fixation of the incinerator ash would be effective in reducing the mobility of the metallic constituents. Actual treatment options will depend upon waste characterization results.

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- On-site washing of the contaminated soils, followed by on-site disposal of the coarse fraction and bioslurry treatment of the fine fraction. This fine fraction contains the majority of the contamination. Treatability testing of site soil and groundwater samples has demonstrated that DEHP can be solubilized from site soils using a 0.5% Brij 30/35 solution. Therefore, this surfactant may be useful in maximizing contaminant removal from soil particles.

- On-site treatment of liquid wash solutions incorporated with on-site treatment of extracted groundwater.

- Testing of treated material to determine the suitability of these materials for use as backfill.

- Backfill site to original grade with treated soils and makeup backfill as required, regrade, and revegetate.

- Long-term (20 years) groundwater monitoring associated with continuing groundwater containment. Monitoring is reduced from 30 years as delineated in Alternative 3 to 20 years since the removal of contaminants contained in the soil phase decreases the primary source of contamination to the groundwater.

Excavation activities are anticipated to encounter groundwater. Due to the high permeability of intermediate zone soils and the large depth to a confining layer (bedrock), it would be impracticable to attempt to dewater the excavation. The large percentage of cobbles and boulders would inhibit the installation of physical barriers to groundwater infiltration (i.e. slurry walls). A vapor barrier foam system may be required to suppress any volatile organic contaminants from adversely impacting the air. Additionally, engineering controls to reduce fugitive dust would likely be required during excavation of vadose zone soils. During extensive excavation, the pit may need to remain open for an extended period to assure that treated soils or clean fill being placed do not become contaminated by soils not yet excavated. Furthermore, saturated, excavated soils may require staging prior to introduction to the treatment train. Fluids (including contaminated groundwater and free product) flowing out of these staged soils could contact and contaminate previously noncontaminated soils, the wetlands, or the Rockaway River. Extensive excavation of contaminated soils adjacent to the wetlands and/or the Rockaway River may cause siltation and sediment loading. These processes would not only adversely impact wetlands in the immediate vicinity of L.E. Carpenter, but by transport by the Rockaway River, may adversely impact wetlands downstream in locations remote from the site.

Soil washing has advantages over other ex-situ treatment technologies involving excavation in that it may have the potential for significantly reducing the volume of solid hazardous materials that require final disposal. Soil washing has a further minor advantage over thermal technologies for excavated soils in that dewatering of the soils prior to treatment is not necessary. However, given site specific conditions (i.e., high water table, location of wetlands and the proximity to the Rockaway River), large scale excavations at the L.E. Carpenter site will be very difficult.

The contaminants that are able to be removed from the influent wastestream are dependent upon the washing solution(s) selected. Soil washing systems able to treat both organically and inorganically contaminated soils have been successfully designed to use a staged application of different wash solutions. However, since this technology does not chemically treat or destroy the contaminants, further treatment of the effluent streams is required prior to final disposition of the wastes. Additionally, oversize particles (those greater than 2 inches in their largest diameter) cannot be introduced to a soil washing system but usually do not contain contamination anyway.

Based on treatability and pilot scale studies, a soil washing system may be designed which will (ideally) scrub both organic and inorganic contaminants out of the coarse fraction of soils to a point where this bulk portion of the soil is amenable to placement in the original excavation. However, several effluent streams will potentially require further treatment. At least one washwater stream will contain solubilized contaminants and additives and will require treatment prior to recycle. Based on a rule of thumb washwater to soil ratio of 10:1, the volume of washwater requiring treatment prior to recycle/discharge would be in excess of 63,600,000 gallons. Dependent upon the solutes in the washwater stream(s), this may be accomplished by physical (membrane separation or carbon adsorption), chemical (advanced oxidation), or biological processes. Air emissions produced by the soil washing operation would be treated by carbon adsorption. The highly contaminated, concentrated fine fraction would also require further treatment. As with the other effluent streams, several treatment options are available based upon the waste characteristics. Dewatering may or may not be required as precursor to further treatment.

If the initial washing process has the ability to clean the influent soils of contaminant to below potential ARAR levels, soil washing would be a technically feasible means of remediating the contaminated soils present at the L.E. Carpenter site.

Figure 6-4 illustrates a typical soil washing system layout. Excavated soils would be staged prior to screening out large rocks (greater than 2-inch diameter). The remaining soil is then fed to a size classification unit where the soil is slurried with water and oversized material are screened from the remainder of the soil. This remainder is fed to a froth flotation unit where hydrophobic material is consolidated into a froth phase and removed. The underflow then enters a vigorous multi-staged counter-current scrubbing circuit in which the coarse fraction is scrubbed and the fine fraction is suspended. The coarse fraction is dewatered and staged for testing/emplacement while the slurried fine fraction is thickened and sent to the bioslurry reactor. Process water is collected, treated biologically and recycled, and emissions may be controlled by scrubbing waters or granular activated carbon treatment. Within the bioslurry reactor, the factors affecting biological degradation of the waste stream, such as oxygen and nutrient availability, temperature, pH, toxicity, and residence time, can be closely monitored and optimized. Treated groundwater may be used for makeup water for the system, and treatability testing along with future Remedial Design may allow the use of the groundwater treatment system to also treat the soil wash recycle water.

A treatability study will need to be undertaken to determine if this technology will treat the contaminated soils to the required limits. It is assumed that site specific cleanup levels would be met prior to disposing of the washed soils as backfill on site. However, the LDR levels for DEHP (28 mg/kg), required for placement of the fine fraction, may be difficult to achieve in a bioslurry reactor.

Slurry bioremediation systems, such as a bioslurry system, are living systems and as such are sensitive to fluctuations in influent quality. Care must be taken to avoid shock loading of contaminants which are inherently toxic to the microorganisms such as metals or highly halogenated compounds. The organic constituent(s) of concern could also be toxic to the microorganisms if the concentration of contaminant(s) is(are) too high. Biological treatment systems require frequent monitoring to ensure proper operation.

Slurry bioremediation requires an aqueous medium in which the bacteria live. Degradation of the contaminants occurs at the organic/water interface. As a result, degradation of dissolved contaminants is more effective than that of immiscible product, where the contaminant's surface area to volume ratio is low. Therefore, soils which contain immiscible product would most likely require preconditioning, including slurrying into a fluid matrix and removal of immiscible product and oversized materials, prior to introduction into the enhanced bioreactor. It is assumed that a significant portion of east site soils contain immiscible product, therefore, enhanced bioremediation of these soils would be most effective as a "finishing" step in combination with soil washing which has the ability to remove the free product and potentially the metals from the soils.

Soil washing has several advantages over other technologies as a preconditioning step for soils being introduced to a slurry bioremediation system. Soil washing classifies feed soil based on size, so that oversized particles, which could cause damage to the equipment, are not introduced to the bioreactors. Most soil washing systems can employ some means of separating out hydrophobic, free product trapped within soil pores. Soil washing does not thermally destroy the native microorganisms in the soil. Biological degradation of the organic contaminant, which are adsorbed on the surface of the fine fraction, is possible while those fines are slurried in the fluid matrix. Additionally, the fines being introduced into the bioreactor will not require dewatering as they would if they were being treated via incineration or stabilization. However, the materials fed into the treatment system must be excavated and staged prior to treatment. Excavating the subsurface soils, which generally contain contaminants in greater concentrations than surface soils, could increase the possibility of contaminant migration to formerly uncontaminated soils, the Rockaway River, adjacent wetlands, and downstream wetlands via sediment loading to and transportation by the river. Further, volatile emissions and contaminated fugitive dust resulting from excavation activities could create a risk pathway (air transport of contaminants) that currently does not exist, and would not result from nonintrusive remedial activities.

6.2.5.2 Compliance with ARARs

Performance of a treatability study and field scale pilot testing will determine the suitability of this alternative to meet ARARs, such as the proposed New Jersey cleanup level of 100 mg/kg for DEHP in soil. Action levels for other soil contaminants are expected to be more easily attained.

While there are currently no regulations that specifically govern the destruction efficiency of nonthermal treatment of contaminated soils, RCRA requires that treatment of wastes that are subject to the land disposal restrictions attain the levels achievable by the best demonstrated available technology for each hazardous constituent in each listed waste. The soil fines being treated in the bioslurry reactor will need to meet LDRs (e.g., 28 mg/kg for DEHP and xylenes) prior to ultimate disposal/placement. Treatment to this low level may prove to be difficult. Additionally, all waste stream extracts must meet TCLP criteria prior to land emplacement of wastes. TCLP testing may indicate that stabilization or some other further treatment of the fines would be necessary prior to backfilling. The action-specific ARARs regarding NJPDES would also be applicable for discharge of treated washwaters. Excavation of subsurface soils contaminated with volatile and semivolatile organic constituents may cause noncompliance with NAAQS. Emissions could result from encountering residual free product floating on the water table, exposing contaminated groundwater to the air, or aerating soils during excavation activities. A substantial effort would be required to reduce emissions of organic contaminants to within acceptable levels.

The portion of the site which would house the treatment equipment is located on a 100-year and 500-year flood plain. In addition, portions of the excavation will take place in this flood plain. The flood plain and its ability to provide drainage in the area must be maintained during on-site activities. In addition, the treatment facility must be designed, operated, and maintained to avoid washout.

Some areas of the L.E. Carpenter site which contain contaminants at concentrations above cleanup goals meet the criteria of wetlands. As determined during the Wetlands Assessment (EcolSciences, Inc., 1992), although soils to be excavated would be replaced, extensive excavation could eliminate most of the existing wetlands communities. Excavation of wetlands adjacent to the Rockaway River would likely cause siltation and sediment loading to the river and possibly negatively impact downstream wetland areas. Aquatic species, such as trout, that depend on visual acuity for feeding would be adversely affected by increased sediment loading in the Rockaway River. Therefore, widescale excavation of these areas may not be permitted and wetland mitigation would be necessary. Further, regulated activities would include construction on or alteration of these areas. Construction of the treatment facility in a wetland is not anticipated.

The construction and operation of the on-site soil washing process may require compliance with applicable state and Federal regulations for a hazardous waste treatment facility, and would further involve compliance with local building codes.

6.2.5.3 Short-Term Effectiveness

In addition to the areas of concern identified for Alternative 3, short-term effects are described below.

Excavation activities could result in fugitive air emissions. These impacts can be both health related and nuisance-related. Utilization of dust and vapor control technologies may help reduce potential emissions. An on-site air monitoring program would provide indications of air quality. Soil washing technology is largely based on abrasion for soil separation and contaminant extraction. As a result, there is a potential for contaminant releases to the atmosphere and subsequent risk of exposure to the community. All dust and vapor emission from contacting units will be directed to an air cleaner or scrubber prior to discharge.

Special precautions should be taken to prevent spills, overflow, and other means of release of contaminated media to the environment from the process or the staged materials. Countermeasures such as spill containment and process modification to prevent recurrence should be designed to provide adequate protection until these difficulties can be resolved.

This process requires a large amount of soil handling, thereby increasing the potential for direct exposure and inhalation of airborne dusts and vapors by site workers and the local community. Inhalation, ingestion and dermal contact with contaminated media must be minimized by utilization of appropriate protective clothing and equipment, and following proper health and safety procedures during site remedial activities.

The primary short-term environmental impact is from the excavation operations. Excavation would remove the relatively noncontaminated surficial soils and increase environmental exposure and potential human exposure to heavily contaminated subsurface soils and residual immiscible product during the excavation process and while soils are stockpiled prior to treatment. Physical hazards associated with open excavations are also a concern.

On-site soil washing provides an environmental benefit by removing/reducing the contaminant concentration in site soils and by reducing the volume of the waste stream. Implementation of this alternative is expected to take eight months for remediation of the soil phase, based on an assumed treatment capacity of 15 to 20 tons per hour, 24 hours a day operation. Continued operation of the groundwater extraction and treatment would provide further protection of the environment.

6.2.5.4 Long-Term Effectiveness and Permanence

For Alternative 5, the remaining sources of potential risk after treatment are due to the soils left in place, re-emplacement of treatment residuals, and remaining contaminated groundwater. Since soils containing contaminants of concern above the cleanup standards will be excavated and treated, the potential risk to the public and environment is greatly reduced. Additionally, the protection provided by groundwater containment/extraction is greatly increased since a source of continuing contamination (the contaminated soils) is being removed. Groundwater collection and treatment would continue to control off-site migration of a contaminated groundwater plume. Additional periodic inspections to check the revegetation and potential erosion affects could be conducted concurrently with continued groundwater treatment to provide a permanent remedy at the site.

The soil washing process may cause negative environmental impacts. If additives are introduced to the wash water to solubilize contaminants, residual amounts of the additives may remain on the cleaned soils and may adversely affect future environmental quality at the site.

6.2.5.5 Overall Protection of Human Health and the Environment

The additional technology(s) applied to the effluent streams will determine if the contaminants may be fully destroyed or immobilized as required. Since these additional technologies are required, the effectiveness of a Remedial Design based on soil washing will depend upon the particle size distribution of the original influent as well as the ability for the wash solutions to scrub clean the bulk of the soil (the coarse fraction). The cost-effectiveness of this option is further dependent upon the effectiveness and cost of the washwater treatment system.

In this alternative, all appropriate ARARs may or may not be satisfied, pending the outcome of a treatability test. The most significant ARARs are chemical-specific. It is not certain whether soil washing can meet chemical-specific ARARs due to process limitations and soil suitability. However, Alternative 5 will reduce risk over the long term since this technology has the potential to significantly reduce the volume of contaminated media on-site to a concentrated waste stream which may be further treated to reduce the toxicity and mobility of contaminants. Location and action-specific ARARs will be met as defined by the appropriate agencies on a case-by-case basis.

A soil washing process may be designed to be applicable to all contaminated soils at the site as a primary technology. However, the additional technology(s) applied to the effluent streams will determine if the contaminants may be fully destroyed or immobilized as required. Since these additional technologies are required, the effectiveness of a Remedial Design based on soil washing will heavily depend upon the particle size distribution of the original influent as well as the ability for the wash solutions to scrub clean the bulk of the soil (the coarse fraction). The cost-effectiveness of this option is further dependent upon the effectiveness and cost of the washwater treatment system.

A potential risk can remain in the treated and backfilled soil, since the contaminant may be present at trace levels. This presence may promote contaminant mobility. Leachate tests should determine whether this is a concern.

Overall impacts of widescale excavation would negatively impact adjacent wetland environments.

6.2.5.6 Reduction of Toxicity, Mobility, and Volume of Contaminants

The on-site soil washing technology addresses the principal threats at the site by removing the source. This process is used to remove, by extraction, both the organic and inorganic compounds from affected soils.

The amount of material treated is estimated at 31,500 yd^3, based upon the proposed soil cleanup level of 100 mg/kg for DEHP. The mass and mobility of the contaminants are not reduced by soil washing. However, the volume of affected media and subsequently the volume the waste is significantly reduced. First, the contaminants are washed off larger particles. These contaminants are extracted and the extractant is then subjected to treatment. This treatment results in a clean extract stream (for recycle to the process) and a concentrated waste stream (for further treatment or disposal). Second, the fines that are carried through the entire process by the extractant contain the majority of the contamination. The extractant and fines are biologically treated to destroy contaminants. Therefore, volume reduction is achieved in a step wise manner, first by removing the coarse particles and second by removing contaminants from fines to produce a concentrated waste stream which is then treated.

Reduction of contaminant mobility and toxicity depends on final treatment of the waste stream. If feasible (based on treatability studies) these fines will be treated by a bioslurry technique which will destroy the organic constituents of the waste.

Alternative 5 satisfies the statutory preference for treatment as a principal element of the alternative.

6.2.5.7 Implementability

Excavation at the L.E. Carpenter site is anticipated to be very difficult. Removal of soils meeting the draft New Jersey cleanup standards would be required to provide access to soils which exceed those criteria. Exposure of these contaminated soils would increase the likelihood of air migration of contaminated dusts and organic vapors. Further, excavation and staging of soils containing free product and contaminated groundwater would further increase the risk of contaminant migration via overland flow of these fluids onto clean surface soils, into the Rockaway River, or onto adjacent wetlands. Contingency measures such as slope stabilization and shoring, runoff/runon controls, and sediment control, will be necessary.

Major limitations are associated with the implementation of Alternative 5 due to the combination of immiscible product recovery, groundwater extraction, and soil removal. Any soil removal conducted during product recovery and groundwater extraction would be severely hampered by the collection piping between the wells and the central collection points, as well as the wells themselves. Excavation should not be conducted until immiscible product recovery has essentially been completed; otherwise, clean soil backfilled into the excavation would become contaminated. The time required for effective removal of immiscible product is uncertain, but may take several years. Therefore, implementation of Alternative 5 would be delayed.

The large area affected and volume of soil to be treated via soil washing will increase the difficulty in implementing this alternative. Difficulties in handling saturated soils, including releases of free liquids while transferring these soils from the excavation to the staging area, may actually increase the areal extent of surface contamination. Overland migration of this material may negatively impact off-site areas. Avoidance of this situation would require substantial diligence and control.

For activities within the flood plain and approval of placing treated soils as backfill at the site, coordination with the appropriate agencies will be necessary. A potentially lengthy permitting process to secure the proper air and water discharge limitations and monitoring requirements may further delay remediation.

Currently, several vendors have transportable soil washing systems capable of extracting contaminants from soil. Prior to full-scale implementation at the L.E. Carpenter site, it is recommended that bench and pilot scale studies be conducted to determine feasibility and to refine engineering and operation parameters. An asphalt pad will be constructed on the western portion of the site to provide a staging area for excavation and treated materials, as well as support for the treatment unit.

6.2.5.8 Cost

The capital cost items identified under Alternative 5 include:

- All cost items required in Alternative 3, with the exception metals and PCB hot spot excavation and incineration. These volumes of soil would be treated via soil washing.

- Additional treatability studies for soil bioslurry reactor.

- Construction of paved staging/treatment area.

- Excavation of contaminated soils.

- Materials treatment and disposal.
  - Capital equipment costs.
  - Energy and extractant costs.
  - Manpower for operation of treatment equipment.
  - Cost of residuals treatment and on-site disposal.

- On-site laboratory for analytical support.

- Reinstallation of groundwater extraction system.

- Site restoration (backfill, grading, seeding, etc.).

- Verification sampling.

Operation and maintenance cost items are associated with the operation of the enhanced product recovery system (0 to 3 years) as well as groundwater containment and treatment (0 to 20 years).

Table 6-5 provides a cost summary for Alternative 5. Using a present worth analysis at 5% compound interest over 20 years, the total present worth estimated cost of Alternative 5 ranges from $22,366,000 to $34,681,000. This range is based on a vendor quote and encompasses the uncertainties associated with the applicability of soil washing to the waste at the L.E. Carpenter site. For example: the costs will vary significantly depending on the number of washings required to meet the cleanup standards. This figure may be further refined based on the results of a treatability and pilot scale study. This cost estimate was performed based on the following assumptions:

- 31,500 yd^3 total requiring excavation and soil washing.
- Soil density (prior to excavation) is 1.5 ton/cubic yard.
- Soil contains 30% by volume of fines (less than 74 microns).
- Soil contains 15% by volume of oversized materials (greater than 2 inches at largest diameter).
- Soil wash unit is sized at 20 tons per hour; 24 hours/day operations with no greater than 25% "downtime".
- Oversized materials and washed coarse fraction are amenable to backfill on site without further treatment.
- Bioslurry unit can treat fines to concentrations required by land disposal restrictions. If fines would require incineration, project costs could increase by $17.6 million.
- Bioslurry treatment is effective on organic constituent in fine fraction, stabilization/fixation technology, if necessary, binds inorganic constituents to allow delisting of characteristic waste for metals.
- Removal of groundwater encountered during excavation is not required.
- Skimming of free product floating on groundwater is accomplished.
- Groundwater and discharge monitoring costs include costs for collection and analysis of appropriate samples, but does not include reporting costs, permit renewal application fees or permit preparation costs. Analyses performed at beginning of remediation will be 600

series, switching to 500 series as the aquifer approaches cleanup levels and a lower detection limit is required to determine compliance with remedial goals.

- Six groundwater recovery wells are installed after soil remediation to allow for continued groundwater remediation. This corresponds to Phase II groundwater recovery for Alternative 3 in that a majority of the treated water would be recirculated within the capture zone while a portion of the water would be "polished" and discharged to the deeper aquifer zone. The actual number and placement of extraction and recharge wells would be determined by sophisticated numerical modeling to be performed during Remedial Design.

6.2.6 Alternative 6: Excavation/Thermal Treatment

6.2.6.1 Description of Alternative

Alternative 6 consists of removal by excavation of a potential source of continuing groundwater contamination (soils containing organic contaminants at concentrations greater than cleanup goals) and destruction of the organic constituents via incineration. Under this alternative, two options (A and B) are considered. The difference in the options is that Option A provides for an on-site incineration to thermally treat the contaminated soils, whereas in Option B, all soils are transported off site to a commercial RCRA permitted incinerator for treatment.

As with Alternative 5, the bulk of soils requiring treatment are from the area to the east of the Railroad Right of Way. The excavation will be backfilled with clean fill. Option A allows for the potential to backfill the excavation with stabilized incinerator ash. All unit processes described in Alternative 3, Groundwater Treatment, will also apply including the two-phased approach to groundwater remediation. These measures will be implemented to assure long-term containment of the contaminated groundwater plume, as well as removal of the risks associated with direct contact exposure pathways for soils containing chemical contaminants at concentrations above the action levels established by the L.E. Carpenter site. The groundwater extraction wells would be replaced after the excavation resulting from removal of the soils was backfilled.

The major components of Alternatives 6A and 6B include:

- Operation of product/groundwater extraction system to remediate floating product layer located under the eastern portion of the site which is a continuing source of groundwater and subsurface soils contamination. The system would operate until the floating layer diminishes to the point where it is no longer feasible to continue operation. This process is described as Phase I in Alternative 3.

- Cap the northern portion of soil located west of the railroad right-of-way to eliminate physical contact exposure pathways for those soils.

- Excavation of contaminated soils to the soil cleanup standards. As with Alternative 5, excavation activities will involve encountering groundwater. Due to the high permeability of the majority of site soils, the large depth to a confining layer (bedrock), and soil conditions which render installation of physical groundwater barriers very difficult, it would be impractical to attempt to dewater the excavation. If necessary, a vapor barrier foam system may be used to suppress any volatile or semivolatile organic contaminants from adversely impacting the air.

- Fixation or direct disposal of isolated hot spot soils contaminated with metals only (non organics) depending on waste classification analytical results.

- Provision of an on-site laboratory for analytical support in assuring excavation of contaminated soils to cleanup standards.

- Implementation of a groundwater containment (extraction and treatment) system to eliminate potential off-site migration of contaminated plume which could adversely affect the groundwater quality of the area. A limited number of extraction wells to allow subsequent groundwater remediation will be replaced following backfill of the treated soils or clean fill, depending on the suitability of treated soils for reemplacement. This system is analogous to Phase II described in Alternative 3, with a portion of extracted groundwater to be recirculated within the capture zone and the remainder to be discharged to the deeper aquifer zone.

- Long-term (20 years) groundwater monitoring associated with continuing groundwater collection and treatment. Monitoring is continued for twenty years since the removal of waste for incineration is limited to immiscible product and contaminants contained in the soil phase.

Additional major components specific to Alternative 6A include:

- Pave the portion of the site between the existing Building 5 parking lot and the north fenceline. This area would be used to operate the on-site rotary kiln incinerator and ancillary equipment and materials staging area.

- On-site incineration of contaminated east site soils with on-site disposal of stabilized residuals in previously excavated areas.

- Backfill excavation to original grade with treated stabilized soils and imported clean fill, regrade and revegetate. Analytical testing of treated material would be performed to determine the suitability of these materials to be used as backfill.

Additional major components specific to Alternative 6B include:

- Transport of excavated soils to a RCRA-permitted commercial incinerator. This may be a lengthy process to complete since many commercial incinerators are currently operating at or near maximum capacity.

- Backfill excavation to original grade with imported clean fill, regrade and revegetate as required.

Thermal treatment of contaminated soils will directly remediate the source of contamination in soils and the source of continuing contamination in the groundwater at the L.E. Carpenter site, thereby reducing subsequent impact to off-site areas.

The first step to incinerating soils is excavating them from their original location. Immiscible product contained within the soil pores above the water table would be excavated along with the soils. Any product floating on the groundwater within an excavation could be skimmed off and added to the soils to be introduced to an incinerator, thereby raising the heating value of the waste.

Incineration destroys organic contamination, as well as the naturally occurring organic content of soils. The major contaminants of concern in site soils are organic chemicals. Therefore, incineration is particularly applicable to the L.E. Carpenter site. There are two potential options for Alternative 6, on-site incineration and off-site incineration. Either technique would be effective in reducing the toxicity, mobility, and volume of the waste. However, to provide a media-wide remedy for the L.E. Carpenter site, incineration would need to be combined with treatment technology(ies) to remediate groundwater contamination.

Unlike the excavated soils being introduced to a soil washing system as described in Alternative 5, excavated soils to be incinerated would need to be dewatered/dried prior to treatment. The water resulting from the dewatering (drying) process would need to be treated prior to discharge. It may be possible to add this stream to the groundwater treatment system influent, thereby reducing the number of discrete waste streams being produced.

For Alternative 6A, excavated contaminated materials will be transported to a dewatering unit as required and then to the on-site incinerator. This incinerator would most likely be a rotary kiln incinerator. Rotary kilns have been extensively tested and successfully used for hazardous waste destruction. They are capable of incinerating waste in any physical form, require little pretreatment of waste, and have fewer feed restrictions than many other incinerator technologies. In addition, many vendors own and market transportable rotary kiln units.

Stabilization could provide an effective means for reducing the mobility of metals in the treated soil waste. Wastes containing leachable metals are generally RCRA characteristic wastes for those waste constituents, rather than RCRA listed wastes. When treatment of characteristic wastes (i.e., via stabilization) reduces the leachability of the metals to below regulatory limits, the wastes are no longer RCRA wastes for those characteristics. Therefore, stabilization is a viable means of rendering metal-containing wastes nonhazardous after their organic content has been removed.

Stabilization of metals in the ash would be performed as required. If the resultant material complies with the delisting criteria for nonhazardous waste, it will be used as backfill in the excavated area. Otherwise, this treated material will be sent off site to a RCRA permitted facility. Scrubber waters generated from the air emissions control system would be treated with the waters produced during initial dewatering of soils prior to introduction into the on-site incinerator.

For Alternative 6B, excavated contaminated materials will be collected in licensed hazardous waste hauling roll-offs for subsequent transport to an off-site RCRA permitted incinerator. The time frame for completion of this remedial alternative would be wholly dependent on the availability of commercial units to accept this waste. Since most currently permitted commercial incinerators are operating at or near capacity and the total volume of soils exceeding cleanup goals is significant, ultimate disposal of the contaminated soils from the L.E. Carpenter site could take several years.

Once the excavated areas have been filled, they will be graded and vegetated to restore the site to its natural condition. Clean fill will be required for Alternative 6B and may be required for Alternative 6A if the treated soils have been reduced in volume or require off-site disposal.

6.2.6.2 Compliance with ARARs

Implementation of Alternative 6A or 6B will result in compliance with appropriate chemical, location, and action specific ARARs. In particular, it is expected that thermal treatment, whether on site as in Option 6A, or off site as in Option 6B, can attain the ARARs for organic compound contamination, including LDRs. Testing of soils/treated soil will determine if it exceeds TCLP limits for metals contamination.

Location specific ARARs regarding flood plain and wetlands considerations have been discussed in Subsection 6.2.5.2 for Alternative 5. Specifically, a wetlands variance and substantial wetlands mitigation would be necessary to counteract the extensive wetlands disturbances resulting from excavation of soils and to comply with wetlands ARARs. In addition, the action specific ARARs regarding discharge to groundwater under NJPDES would be applicable. Further action specific ARARs for Alternative 6A include the following:

- State permits will be required for on-site thermal treatment. Regulatory approvals would be needed for the treatment unit, air emissions, water discharge from scrubbers, and on-site ash disposal.

- A trial burn will be required to demonstrate destruction and removal efficiency (DRE) for the organic constituents in the soils. For organic constituents in the waste feed material, a DRE of 99.99 percent must be demonstrated for each principal organic hazardous constituent (POHC). For PCBs, a DRE of 99.9999 percent is required.

- The construction and operation of an on-site thermal treatment unit would require compliance with applicable state and federal regulations for a hazardous waste treatment facility.
- Treatment residuals must comply with the delisting process before being disposed of onsite and must be reclassified as nonhazardous.
- Construction of a staging area on-site may involve compliance with local building codes and be engineered to avoid washout if located within the 100-year or 500-year floodplain.

Action specific ARARs for Alternative 6B include the requirements of the U.S. Department of Transportation (DOT) for the transportation of hazardous materials to the commercial incinerator. State hazardous waste manifesting and permitting/licensing requirements will have to be met. If limited availability of commercial incinerators require on-site storage of excavated hazardous materials for longer than 90 days, the requirements of NJAC 7:26-9.1 et. seq. regulating the treatment, storage, and disposal of hazardous wastes must also be met.

6.2.6.3 Short-Term Effectiveness

For on-site thermal treatment, Alternative 6A, the major short-term risk to the community is from air emissions. These emissions must meet applicable state and federal air regulations. Incinerator emissions are controlled by off-gas treatment systems that are attached to the main process unit. An on-site air monitoring program will be implemented to provide protection and warning to on-site workers and the surrounding community if regulatory levels are exceeded. Workers will also be provided with the appropriate personal protective equipment to protect against the hazards of operating the on-site incinerator.

For Alternatives 6A and 6B, fugitive air emissions resulting from the widespread excavation of contaminated soils are a concern, as they were for Alternative 5. Dust and vapor emissions monitoring will be conducted and, along with erosion and sedimentation control measures, will minimize the potential short-term environmental impacts resulting from either Alternative 6A or 6B.

Both on-site and off-site thermal treatment provide an environmental benefit by permanently destroying the organic constituents of the waste. It is anticipated that Alternative 6A will require approximately 18 months to implement for remediation of contaminated soils based on an incinerator feed rate of 5 to 7 tons/hour with no more than 25% "downtime". The implementation schedule for Alternative 6A would be proposed by the time required for mobilization, permitting, and performing a trial burn for the on-site incinerator, which could take several years. Alternative 6B is estimated as requiring 15 months to excavate contaminated soils for shipment to commercial incinerator(s). The groundwater remedy portion (as described in Alternative 3) of each option of Alternative 6 is expected to continue for 20 years, since the source of continued contamination to the groundwater (the organic constituents in the soils) will be removed with the bulk of the contaminated soils.

6.2.6.4 Long-Term Effectiveness and Permanence

In Alternative 6A, as in Alternative 5, the treated soils are expected to be backfilled on site. A reduction in long-term risk is anticipated as a result of treatment of contaminated soils and backfill of treatment residuals. Likewise, a reduction in long-term risk is anticipated as a result of excavation and transport of contaminated soils off site for incineration as proposed in Alternative 6B.

For both options the remaining sources of risk after treatment of soils are due to the soils left in place and the remaining contaminated groundwater. Alternative 6A has an additional source in the backfilled treatment residuals. For both options, since all soils above health-based risk levels will be excavated and treated, the risk to the public and environment is greatly reduced. As with Alternative 5, the efficiency of the protection provided by groundwater containment/extraction is greatly increased since the contaminated soils (the source of continuing groundwater contamination), are removed. Replacing the extraction wells after excavation, and continuation of the groundwater collection and treatment system would eliminate off-site migration of a contaminant plume. Periodic inspections of wetlands mitigation effects and the revegetation could be conducted throughout the life of groundwater treatment program to ensure long-term effectiveness of the remedial action.

6.2.6.5 Overall Protection of Human Health and the Environment

In both options of Alternative 6, all appropriate ARARs will be satisfied. Over the long-term, each incineration option will reduce or eliminate the risk of exposure to contaminants by potential receptors.

As with Alternative 5, primary concerns include the implementation of remedial actions at the site and short-term effectiveness. In addition to the concerns associated with excavation and earth moving activities for both options of Alternative 6, air emissions and fugitive dust controls must be implemented for Alternative 6A to ensure adequate protection of human health and the environment during remedial strategy implementation. Adjacent wetlands would be negatively impacted by any widescale excavation process.

6.2.6.6 Reduction of Toxicity, Mobility, and Volume of Contaminants

Both on-site and off-site thermal treatment options address the principal threats at the site by removing and destroying the source of organic contamination to the groundwater. As with Alternative 5, the volume of contaminated soils to be treated is estimated at 31,500 cubic yards. Incineration of these soils reduces the toxicity, mobility, and volume of the organic constituents by thermally destroying them. Chemical fixation is then utilized to reduce the mobility and toxicity of the remaining metals in the ash, as necessary. Furthermore, the groundwater containment treatment phase of Alternative 6 is effective in reducing the mobility of the contaminant plume from the L.E. Carpenter site.

Treatment by incineration is an irreversible operation. The residuals which remain are usually sterile treated soils or occasionally, a slag-like material. Both options of Alternative 6 satisfy the statutory preference for treatment as the principal element of a remedial action.

6.2.6.7 Implementability

As noted in Alternative 5, implementation of excavation at the L.E. Carpenter site would be very difficult for both options of Alternative 6. In order to avoid contamination of clean fill by soils not yet excavated or floating product, the excavation may need to remain open for a potentially lengthy period. Staging of soils prior to treatment will allow for contaminant migration via the air pathway (organic vapors and contaminated soil particles disturbed during earth moving activities) and through the free liquids (product and contaminated groundwater) which could flow overland to the Rockaway River, clean soils, or the wetlands. Additional implementability concerns for Alternative 6A include the potentially lengthy process to permit an on-site incinerator for hazardous waste destruction. A trial burn of the site soils will determine the destruction efficiency of the principal organic hazardous constituents (POHCs) and performance of the air emissions controls. Effluent streams from the incinerator will include gaseous emissions and an ash product. Scrubbers will likely be required to control particulate and vapor emissions that result from incineration. Treated soils or ash generated during the trial burn will be analyzed to verify that it can be designated as a nonhazardous waste. Should analysis indicate that metals will leach from the process residuals at levels above the TCLP Extract limits, further treatment, such as stabilization, will have to be performed on the ash to fix the metals, to allow disposal as nonhazardous waste.

For Alternative 6B, a major implementability concern is the availability of commercial incinerators to accept waste. Due to the limited number of commercial incinerators and the recent promulgation of RCRA LDRs, the demand for incineration of hazardous materials has surpassed the availability. Additionally, the low heating value and high ash content of contaminated soil makes it a less than ideal waste stream for incineration. Therefore, commercial incinerators may only accept this waste stream in small volumes over an extended time frame.

6.2.6.8 Cost

Capital cost items identified for both options of Alternative 6 include:

- Deed notation and land use restriction.
- Product extraction (trench) system.

- Groundwater treatment system.

- Excavation of contaminated soils.

- On-site laboratory for analytical support.

- Construction of paved staging/treatment area.

- Site restoration (backfill, grading, seeding, etc.).

- Relocation of the groundwater collection after excavation activities.

- For costing purposes, it was assumed that the groundwater treatment system would be amenable for treatment of water produced during soil dewatering. As with Alternative 3, an operable unit specific to metals removal during water treatment was not included. If such a unit is required (determined during Remedial Design), such a unit will be added to the treatment train.

- Six groundwater monitoring/recovery wells are installed after soil remediation to allow for continuation of groundwater remediation. This corresponds to Phase II groundwater recovery in Alternative 3, in that a majority of the treated groundwater will be recirculated within the capture zone, which the remaining water will be polished prior to discharge to the deeper aquifer zone.

- Treatment and/or disposal of isolated hot spot soils contaminated with metals only.

The capital cost items specific to Option 6A include:

- On-site materials treatment and disposal.
  - capital equipment costs.
  - supplemental fuel costs.
  - manpower for on-site incinerator operation.
  - cost for residuals treatment and disposal.

- Cost for permitting and trial burn.

The capital cost items specific to Option 6B include:

- Transportation to commercial incinerator(s).

- Off-site thermal treatment and residuals disposal.

For the case of Alternative 6B, all cost factors (i.e., engineering and construction management, and site services) except the contingency fee were applied to the total of capital costs less transportation and thermal treatment costs. These fees are applicable to on-site services; therefore, costs associated with off-site treatment do not apply. However, for Alternative 6A, the contingency factor was applied to the total of all costs for that alternative.

Table 6-6 provides a cost summary for Alternative 6A. Using a present worth analysis at 5 percent compound interest over 20 years, the total present worth estimated cost of Alternative 6A is $46,481,000. This cost estimate was performed based on the following assumptions:

- 31,500 cubic yards of soil requiring excavation and treatment.
- Soil density is 1.5 ton/cubic yard prior to excavation.
- Dewatering of excavation is not required.
- Soil contains 15 percent by volume oversize materials (greater than 2 inches at largest diameter).
- Oversize materials are amenable to backfill on site.
- On-site rotary kiln incinerator is sized to operate at 5 to 7 ton/hour; 24 hour/day operation with no greater than 25 percent "downtime".
- Feed soil contains 20 percent by weight moisture.
- Incineration followed by subsequent fixation of metals in ash renders soil nonhazardous to allow the treated ash to be backfilled on-site.
- State and local authorities and local residents allow operation of on-site incinerators to remediate hazards at L.E. Carpenter site.
- Groundwater and discharge monitoring cost include cost for collection and analysis of appropriate samples, but do not include reporting costs or permitting application or preparation costs/fees. Analyses performed near beginning of remediation is 600 series, switching to 500 series analysis as aquifer approaches cleanup levels and lower detection limit is required to determine compliance with remedial goals.

Table 6-7 provides a cost summary for Alternative 6B. Using a percent worth analysis at 5 percent compound interest over 20 years, the total present worth estimated cost of Alternative 6B is $87,630,000. This figure is extremely dependent upon the cost per ton charged by commercial incinerators for destruction of hazardous wastes, and may change based on the burn characteristics of the soil and the increasing cost per ton being charged by commercial incinerators.

This cost estimate was performed based on the following assumptions:

- 31,500 cubic yards of soil requiring excavation and treatment.

- Soil density is 1.5 ton/cubic yard prior to excavation.

- Oversize material can be treated at commercial incineration unit.

- Commercial incinerators can accept an average of 110 tons of soil per day, 7 days/week, throughout length of soils remediation phase.

- Local access roads are acceptable for continued transport of heavy vehicles.

- Removal of groundwater encountered during excavation is not required.

- Groundwater and discharge monitoring costs include costs for collection and analysis of appropriate samples, but does not include reporting costs or permit reapplication or preparation costs/fees.

6.3 COMPARATIVE ANALYSIS OF ALTERNATIVES

In the following analysis, the alternatives are evaluated in relation to one another for each of the evaluation criteria identified in Subsection 6.1. The purpose of this analysis is to identify the relative advantages and disadvantages of each alternative. These remedial alternatives, named after the primary remedial approach featured in each alternative, are:

- Alternative 1: No Action
- Alternative 2: Institutional Controls
- Alternative 3: Groundwater Treatment
- Alternative 4: Groundwater Treatment with Reinfiltration
- Alternative 5: Excavation/On-Site Soil Washing/Bioslurry Treatment
- Alternative 6: Excavation/Thermal Treatment

6.3.1 Overall Protection of Human Health and the Environment

Alternative 1 offers the lowest degree of overall protection. The overall protection of Alternative 1 can be quantitatively evaluated through the baseline RA, which indicated potential concerns with human health risks due primarily to the presence of DEHP and PCBs in soil and DEHP, xylenes, and ethylbenzene in groundwater. Therefore, this alternative is judged as not meeting this evaluation criterion.

By restricting access and groundwater usage at the site, Alternative 2 provides greater protection of human health and the environment than Alternative 1. Wader/swimmer, and hypothetical future resident exposure scenarios would be eliminated. Surface runoff which may pick up surface soil from the site could possibly discharge to the Rockaway River. However, most of the soil contaminants are located at depths of three feet or more (nearer the water table) and would not be picked up in surface runoff. The remaining exposure scenario, future on-site worker, would allow the potential for contact with contaminated soil (e.g., during possible future regrading, construction, or excavation activities), which would not be protective of human health. In addition, the potential for off-site migration of contaminated groundwater would not be mitigated under this alternative. Therefore, this alternative is judged as approaching but not completely meeting this evaluation criterion.

Alternatives 3 through 6 each involve groundwater extraction and treatment that would reduce on-site groundwater contamination and mitigate the potential for further off-site migration of contaminated groundwater. Alternative 4 provides the potential for in situ treatment through the infiltration of oxygen and nutrients into the subsurface. Therefore, Alternative 4 would be more protective with respect to groundwater contamination than the other alternatives.

Alternatives 3 and 4 preclude direct contact with surface soils through the installation of a soil cover. In Alternatives 5 and 6, contaminated soil is excavated to the extent possible and treated either on site or off site. The flushing of soil via groundwater extraction will aid in the removal of soil contaminants in the saturated zone. If future intrusion into subsurface soils at the site is precluded, then Alternatives 3 through 6 are equally protective of human health and the environment.

6.3.2 Compliance with ARARs

Table 6-8 provides a comparative summary of the compliance of the six alternatives with ARARs previously identified in Section 2. Based upon this comparative analysis, Alternatives 1 and 2 were judged to have deficiencies in ARARs compliance. These alternatives include no provisions to meet chemical-specific requirements (MCLs and proposed cleanup levels) which are exceeded in site groundwater and soil. It should be noted that the draft New Jersey soil cleanup criteria are not ARARs but TBCs. AWQC for lead was exceeded in the Rockaway River in the upgradient sample, so it is not likely that action at the site would allow attainment of the AWQC.

Alternatives 3 through 6 employ bioremediation for groundwater treatment. A treatability study performed on L.E. Carpenter groundwater indicated that bioremediation of target organic compounds in the groundwater is effective. Treatment will be accelerated under Alternative 4 due to reinfiltration of amended groundwater and the possibility of in situ treatment. It is expected that biotreatment of groundwater containing DEHP, ethylbenzene and xylenes will attain ARARs.

Under Alternative 3, soils containing DEHP in excess of the proposed cleanup standard of 100 mg/kg would remain on site for a period subject to natural remedial attenuation processes. Under Alternative 4, areas containing soils exceeding 100 mg/kg DEHP concentration will be consolidated. Treated groundwater amended with oxygen, nutrients, and perhaps a surfactant, will be recycled within the CAMU to the extent possible to facilitate removal and degradation of adsorbed contaminants. Soil samples will be collected after groundwater treatment levels have been met to confirm that DEHP concentrations in soil are acceptable. Alternatives 5 and 6 are also expected to meet the proposed New Jersey cleanup standards. DEHP adsorbs strongly to fine particles and organic matter, which will be removed under Alternative 5. DEHP would be essentially destroyed by incineration in both options of Alternative 6.

Because they require excavation of DEHP contaminated soil, Alternatives 5 and 6 will be required to meet the LDRs, which are more stringent than the New Jersey cleanup standards for DEHP and xylenes. Other alternatives need to meet LDRs for some hot spot remediation, where applicable. Furthermore, extensive wetlands mitigation for Alternatives 5 and 6 would be required to limit the negative impacts of excavation (and associated disruptions including increased siltation to the Rockaway River and possible disturbance of downstream wetlands) of large volumes of soil.

Each alternative is anticipated to meet action- and location-specific ARARs at the site.

6.3.3 Long-Term Effectiveness and Permanence

This evaluation focuses on defining the extent, adequacy, and reliability of the measures that may be required to manage the residual risk from untreated materials or treatment residues. Alternatives that afford the highest degrees of long-term effectiveness and permanence are those that leave little or no waste remaining at the site such that long-term maintenance and monitoring are minimal and reliance on institutional controls is minimized.

Alternatives 1 and 2 offer limited long-term effectiveness and permanence since, with the exception of immiscible product collection, contaminated media will remain untreated, with the potential for long-term migration of contaminated groundwater. Therefore, both alternatives were judged not to meet this evaluation criterion.

Alternatives 3 through 6 offer long-term effectiveness and permanence through the groundwater extraction and treatment component in each. However, Alternative 3 will not be as effective in reducing vadose zone soil contamination as a potential long-term contaminant source, thus extending the time required for groundwater treatment. Alternatives 4 (through in situ treatment), 5 and 6 (through removal) address these soils. Further site use would have to be restricted to nonintrusive activities for Alternative 3 so the DEHP contaminated soils under the cover are not contacted. Restricting future use to this extent may be difficult to ensure. Each of the six alternatives include long-term groundwater monitoring. Groundwater monitoring under Alternatives 3 through 6 is also required to track the progress of groundwater remediation.

Alternative 4 minimizes site soil contaminants remaining through in situ treatment of the targeted material, Alternative 5 by excavation, removal, and treatment of the fine soil fraction containing the contaminants, and Alternative 6 through excavation and thermal treatment of bulk soils at the site. Long-term maintenance of the soil cover will be required for Alternatives 3 and 4. The groundwater infiltration system under Alternative 4 will need to be maintained and controlled for clogging due to excessive biological growth.

Treatability testing would be required to determine the effectiveness of biological treatment of groundwater (Alternatives 3, 4, 5 and 6) and soil (Alternatives 4 and 5), as well as soil washing (Alternative 5). A trial burn would be required as an integral part of Alternative 6, Option A.

Overall, Alternative 3 is judged to meet the long-term effectiveness and permanence criterion, and Alternatives 4, 5 and 6 are judged to exceed the criterion.

6.3.4 Reduction of Toxicity, Mobility, and Volume of Contaminants Through Treatment

Alternatives 1 and 2 do not offer reduction in toxicity, mobility, or volume of contaminated materials through treatment, except for the collection of immiscible product, which is burned off site. Contaminants in the groundwater and soil would naturally attenuate.

Alternative 3 offers contaminant reduction through the active recovery of floating product and treatment of groundwater and remediation of isolated hot spot surface soils. Some contaminants would leach from saturated soils into the groundwater and also be extracted. However, much of the soil contamination would not easily leach into groundwater, and would rely on natural remedial and attenuation processes.

Alternatives 4 would offer additional contaminant reduction by employing in situ soil treatment. Alternative 5 offers similar contaminant reduction via soil washing and subsequent biological treatment of the soil slurry. The soil washing step in Alternative 5 reduces the volume of soil to be treated by removing the relatively clean, coarse soils prior to treatment. Alternative 6 reduces the toxicity of the soil, with minimal volume reduction. Metals in the ash may need to be fixated to reduce mobility.

The layout of the groundwater recovery and extraction system will control the migration of immiscible product and groundwater contaminants ethylbenzene, xylenes, and DEHP. DEHP is particularly adsorbent to soil, so stabilization measures to control its migration through soil (in addition with groundwater collection) are not warranted.

Overall, Alternative 3 was judged to meet this evaluation criterion, while Alternatives 4, 5 and 6 were judged to exceed it.

6.3.5 Short-Term Effectiveness

This criterion involves consideration of community and site personnel protection and environmental impacts during implementation of remedial actions.

Because Alternative 1 involves no further remedial action, this criterion is not applicable. As Alternative 2 involves limited institutional controls, implementation would not entail significant adverse human or environmental impacts. Therefore, Alternative 2 is judged to exceed this evaluation criterion. It should be noted that this judgment is based strictly on the limited nature of the remedial action involved in implementing this alternative.

Of the remaining alternatives, Alternatives 3 and 4 are anticipated to have the greatest short-term effectiveness. Some particulate emissions during the cover installation is anticipated; however, dust control methods should reduce this risk. Furthermore, most of the soil contamination is in the subsurface.

Alternatives 5 and 6 offer a lower degree of short-term effectiveness due to the intrusive soil removal activities. Fugitive air and dust emission control measures would be required during excavation and movement of soils due to the potential release of soil particulates and volatilization of organics on the water table and adjacent soils. During excavation activities, extensive wetlands disturbances are expected due to disruption of the existing topography, and increased siltation and sediment loading. Furthermore, the groundwater collection system would have to be temporarily abandoned during the excavation due to well destruction as their supporting soils are removed. Physical hazards associated with open excavation are also a concern, as is the possibility of contamination migration to the river if the wall between the excavation and the river were breached. Therefore, major limitations are associated with the short-term effectiveness of Alternatives 5 and 6.

6.3.6 Implementability

This criterion determines the technical and administrative feasibility of implementing an alternative. Because Alternative 1 involves no further remedial action, this criterion is not applicable. Since Alternative 2 involves institutional controls only, implementation would not present significant efforts. Therefore, Alternative 2 is judged as exceeding this evaluation criterion. It should be noted that this judgment is based strictly on the limited nature of action involved in implementing this alternative.

With regard to groundwater remediation, Alternatives 3 and 4 offer a relatively high degree of implementability. Well installation techniques are readily available and easily implemented. Phase II of active recovery could begin as soon as a groundwater treatment system is treatability tested, built, and approved. Phase I active product recovery would be operational prior to that time. Extraction well pump tests and setup of the biological treatment system are fairly straightforward. Optimal coordination of pumping rates for product and groundwater extraction would be established during start-up to ensure that the flow gradient for the immiscible product remained toward the extraction system. Under Alternative 4, the treated groundwater infiltration system would be installed prior to placement of the 1-ft soil cover. Several considerations remain in determining implementability of Alternative 4. These considerations include the rate of treated groundwater recycling allowable for site hydraulics, and the reactivity (both desorption and biological degradation) of contaminants adsorbed to site soils.

Major limitations are associated with the implementation of Alternatives 5 and 6 due to the combination of immiscible product recovery, groundwater extraction, and soil removal. Any soil removal conducted during product recovery and groundwater extraction would be severely hampered by the collection piping between the wells and the central collection points, as well as the wells themselves. Excavation should not be conducted until immiscible product recovery has been completed; otherwise, clean soil backfilled into the excavation would become contaminated. The time required for effective removal of immiscible product is uncertain, but may take several years. Therefore, implementation of Alternatives 5 and 6 would be delayed.

In addition, excavation of soil would be severely hampered by the high water table at the site. Frequent cave-ins of side slopes are likely, especially proximate to the Rockaway River. This could cause a breach in the wall separating the excavation and the river. The resulting contact between river waters and the soils being excavated would increase the potential for direct contaminant flow into open waters of the state, and possibly impact downstream wetlands. Excavations may need to be dewatered, at the risk of disrupting gradients established by the groundwater extraction system. Dewatering excavations near the Rockaway River and the drainage ditch may prove ineffective. As soils are excavated and staged, fluids contained in the pore spaces, such as free product and contaminated groundwater, could flow over remaining clean surface soils and to the river or adjacent wetlands. Extensive excavation could negatively impact adjacent wetlands.

Alternative 6A has an additional limitation in that hazardous waste incinerators are perceived as "bad neighbors" by a majority of the general populace. A "NIMBY" (not in my backyard) attitude could delay the approval process for allowing an incinerator to be located in an industrial/residential neighborhood, and located along a riverbank. A protracted legal battle prior to the approvals necessary to implement this option could postpone the start of the remedial action indefinitely.

Overall, Alternatives 2 and 3 exceed this evaluation criterion and Alternative 4 meets this criterion. Major limitations are involved in implementing Alternatives 5 and both options of Alternative 6.

6.3.7 Cost

Present worth costs were estimated for each alternative and are presented in Table 6-9. The costs, which represent order-of-magnitude level estimates, are based on estimates from vendors, engineering and technical analysis unit costs, construction unit costs, conventional cost estimating guides, and prior experience. The actual costs of the project will depend on true labor and material costs, actual site conditions, competitive market conditions, final project scope, implementation schedule, and other variable factors.

For estimating purposes, biological treatment, with a switch to carbon adsorption after 6 to 10 years of treatment, has been assumed for groundwater treatment in Alternatives 3, 4, 5 and 6. If further testing indicates that biological treatment would not be effective in attaining ARARs given the low groundwater concentrations, carbon adsorption or advanced oxidation may be implemented at additional costs.

6.3.8 Recommendation

A summary of each remedial alternative with respect to the evaluation criteria is presented in Table 6-9. As noted in the table, Alternatives 3 and 4 meet or exceed each of the non-cost evaluation criteria, although Alternative 3 does not meet the draft New Jersey soil cleanup criteria, which are TBCs. All other alternatives considered were found not to meet and/or have major limitations with at least two of the non-cost evaluation criteria.

Alternative 4 exceeds the performance of Alternative 3 in compliance with ARARs, in long-term effectiveness and permanence, and in reduction in toxicity, mobility, and volume of contaminants, while the two alternatives were judged to be roughly equal in the other evaluation criteria. Therefore, Alternative 3 (Groundwater Treatment) or Alternative 4 (Groundwater Treatment with Infiltration) are the recommended alternatives.

SECTION 7.0

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APPENDIX A

TABLES

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WESTON MANAGERS DESIGNERS/CONSULTANTS

TABLE 1-1

CHRONOLOGY OF INVESTIGATIVE AND REMEDIATION ACTIVITIES

DATE	ACTIVITY	DESCRIPTION
1982	Remediation of surface impoundment Remediation and closure of starch drying beds	Excavation of 4,000 cubic yards of sludge and contaminated soils from former surface impoundment. Excavation and removal of starch drying beds.
1982	Installation of groundwater monitoring system and immiscible product recovery wells	Installation of a network of ten groundwater monitoring wells used to monitor extent of groundwater contamination and free product thickness. Five of the wells were equipped with skimmer pumps to recover floating product.
1984	Initiation of passive recovery of floating product	Passive recovery system utilizing skimmer pumps in monitoring/recovery wells began operation.
1989	Completion of remedial investigation	Completion of a soil gas survey, test pit and soil sampling, monitoring well installation and sampling, air sampling, and stream sediment and surface water sampling.
August 1989	Supplemental remedial investigation	Additional sampling of soil, test pit installation, surface water sediment, and background soils/sediment.
Sept. 1989	Asbestos removal	Building 12, 13, and 14
January - March 1991	Decommissioning and tank closure	Decontamination and excavation of 16 storage tanks in accordance with NJDEPE approved Closure Plan.
March 1991	Additional sediment sampling	Collection of seven sediment samples from the Rockaway River including two from upgradient locations.
June 1991	Additional groundwater sampling	Sample collection from MW-13s and MW-S3i to confirm presence/absence of phthalate compounds. Also included installation and monitoring of MW-21 on Wharton Enterprises.
June 1991	Installation of recovery wells	Installation of three additional recovery wells as part of the enhancement of the immiscible product recovery system.

TABLE 1-1 (continued)

CHRONOLOGY OF INVESTIGATIVE AND REMEDIATION ACTIVITIES

DATE	ACTIVITY	DESCRIPTION
Sept. 1991	Decontamination and decommissioning of structures in Buildings 13 and 9	Decontamination and dismantling of former process piping, tanks, etc. in Building 13; decontamination of building 9 interior.
Dec. 1991 - January 1992	Demolition of Buildings 12, 13, 14	Buildings 12, 13, 14 razed.
January 1992	Disposal area investigation	Installation of nine test pits in order to investigate and delineate the aerial extent of a former disposal area.
February 1992	Installation and sampling of additional groundwater wells	Installation and monitoring of four new shallow groundwater wells; two on Air Products property and two on Wharton Enterprises property.
Sept. 1992	Ecological Assessment of Rockaway River	Collection of sediment samples at six location to characterize Rockaway River environments upstream, adjacent to and downstream of L.E. Carpenter and evaluate potential biological impairment.
January - February 1993	Well Point Installation	Installation of twenty-three temporary well points to further delineate extent of floating product at site.
March 1993	Gamma Logging Program	Geophysical logging via down-hole natural-gamma ray logging of thirty-four wells, well points and piezometers to develop a better understanding of site stratigraphy.

WESTON MANAGERS DESIGNERS/CONSULTANTS

TABLE 1-2

CHRONOLOGY OF DOCUMENT PREPARATION

DATE	DOCUMENT TITLE
June 1990	Revised Report of Remedial Investigation Findings
July 1990	Supplemental Remedial Investigation Work Plan
November 1990	Supplemental Remedial Investigation, L.E. Carpenter and Company Facility, Wharton, New Jersey
November 1990	Baseline Risk Assessment, L.E. Carpenter and Company Facility, Wharton, New Jersey (Draft)
April 1991	Draft Feasibility Study Report, L.E. Carpenter and Company Facility, Wharton, New Jersey
May 1991	Baseline Risk Assessment, L.E. Carpenter and Company, Wharton, New Jersey (Final)
June 1991	Additional Sediment Sampling Results: Supplemental Remedial Investigation Sampling
August 1991	Supplemental Groundwater Sampling, L.E. Carpenter and Company, Wharton, New Jersey
November 1991	Stage 1A Archeological Survey of the L.E. Carpenter and Company Property, Wharton Borough, Morris County, New Jersey
January 1992	Wetlands Assessment Report for L.E. Carpenter and Company Facility, Wharton Borough, Morris County, New Jersey
January 1992	Baseline Risk Assessment
September 1992	Final Supplemental Remedial Investigation Report for L.E. Carpenter and Company
November 1992	L.E. Carpenter and Company, Draft Final Feasibility Study Report
March 1993	Rockaway River Sediment Ecological Assessment, L.E. Carpenter and Company, Wharton, New Jersey

WESTON MANAGERS DESIGNERS/CONSULTANTS

TABLE 1-3

WELLS LOGGED AND ELEVATION OF CLAY INTERVALS

Well Number	Elevation of Clay Intervals (feet)		
	1st Clay Interval	2nd Clay Interval	3rd Clay Interval
MW-03	619-615	612-606	
MW-04	625-623(1)		
MW-05	627-624		
MW-06	623-612(1)		
MW-07	624-620		
MW-10	621-611		
MW-11d	619-615		
MW-15i	629-626	611-605	
MW-17d	625-623	603-602	
MW-18d	624-621		
MW-21	621-618	616-614	
RW-01	625-621		
RW-02	628-625		
GEI-2I	630-627	624-621	617-613
MW-22	626-620		
WP-A1	631-626(1)		
WP-A2	636-635		
WP-A4	635-629		
WP-A5	631-629		
WP-A6	629-627		
WP-A7	633-122		
WP-A8	632-631		

TABLE 1-3 (Continued)

WELLS LOGGED AND ELEVATION OF CLAY INTERVALS

Well Number	Elevation of Clay Intervals (feet)		
	1st Clay Interval	2nd Clay Interval	3rd Clay Interval
WP-A9	635-632		
WP-B1	629-622[1]		
WP-B2	629-621[1]		
WP-B4	627-625		
WP-B5	628-626		
WP-B6	628-627	623-621	
WP-B7	626-619[1]		
WP-B8	626-621		
Wells Where Clays were Absent or Thin			
RW-03	-	-	-
MW-09	-	-	-
MW-14i	-	-	-
MW-12i	-	-	-

(1) Bottom of log terminated in clay.

TABLE 1-4

POTENTIAL EXPOSURE SCENARIOS, PATHWAYS, AND RISK LEVELS

Exposure Scenario	Pathway	Potential Carc. Risk		Hazard Index	
		Average	95% Limit	Average	95% Limit
On-Site Worker	Soil	1.4E-5	8.2E-4	0.35	1.1
Trespasser	Soil	4.4E-7	2.6E-5	0.021	2.1
Wader/Swimmer[a]	River sediment	1.3E-6	7.9E-6	0.0096	0.32
	River surface water	2.0E-7	2.1E-7	0.0085	0.013
Child/Adult[b]	Fish ingestion	6.2E-4	6.3E-4	1.6	1.6
Hypothetical future resident[a]	Shallow groundwater	3.5E-4	0.015	17	413
	Intermediate groundwater	1.1E-4	1.3E-4	0.55	4.4
	Deep groundwater	8.4E-6	4.0E-4	0.11	6.2
	Soil	3.8E-5	1.9E-3	2.7	79
	River sediments	1.3E-6	7.9E-6	0.0096	0.32
	River surface water	2.0E-7	2.1E-7	0.0085	0.013
	Fish ingestion	6.2E-4	6.3E-4	1.6	1.6

[a] Risk levels to be revised based on a change in NJDEPE guidance and additional sampling results.

[b] Potential carcinogenic risks are for adult and child. Hazard indices are for a child. Adult hazard indices are lower.

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TABLE 1-5

MEDIA SPECIFIC CONTAMINANTS OF CONCERN FOR THE L.E. CARPENTER SITE

MEDIA	CONTAMINANT
Soil, Groundwater	DEHP
Soil, Groundwater	Xylenes
Soil, Groundwater	Ethylbenzene
Soil, Groundwater	Antimony
Soil - Hot Spots	Lead
Soil - Hot Spots	PCBs
Groundwater	Arsenic

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TABLE 2-1

GROUNDWATER/DRINKING WATER ARARs[a](ug/L)

Parameter	NJSDWA MCLs	FSDWA MCLs	New Jersey Groundwater Quality Criteria[b]
Bis (2-ethylhexyl)phthalate (DEHP)		6	30[q]
Butyl benzyl phthalate		100[p]	100[q]
1,1-Dichloroethane			70
1,2-Diethylbenzene			
2,4-Dimethylphenol			100
Di-n-butylphthalate			900
Di-n-octylphthalate			100
Isopropyl benzene			
n-Butylbenzene			
n-Decane			
N-Nonane			
Phenol			4,000
1,2,3,4-Tetramethylbenzene			
1,2,3-Trimethylbenzene			
1,2,4-Trimethylbenzene			
1,3,5-Trimethylbenzene			
1,2-Dichloroethane	2	5	2[q]
1,1-Dichloroethene	2	7	2[q]
1,2-Dichloroethene (total)	10	70 (cis) 100 (trans)	10 (cis) 100 (trans)
Diethylphthalate			5,000
Ethylbenzene	700	700	700
1-Ethyl-3-methylbenzene			
Methylene Chloride	2	5	2[q]
Naphthalene			
Tetrachloroethylene	1	5	1[q]
Toluene	1,000	1,000	1,000[q]

TABLE 2-1 (Continued)

GROUNDWATER/DRINKING WATER ARARs[a](ug/L)

Parameter	NJSDWA MCLs	FSDWA MCLs	New Jersey Groundwater Quality Criteria[b]
1,1,1-Trichloroethane	26	200	30[q]
Trichloroethylene	1	5	1[q]
Xylenes (total)	44	10,000	40[q]
Antimony		6	20[q]
Arsenic	50	50	8[q]
Chromium	100	100	100
Chromium (VI)			
Copper	1,000[s]	1,300[d]	1,000[q]
Lead	50[c]	c	10[q]
Nickel		100	100
Selenium	50	50	50
Zinc	5,000[s]	5,000[s]	5,000

a - When two or more values conflict, the lower value is generally used, if equally applicable.

b - Groundwater Quality Standards, N.J.A.C. 7:9-6 et seq. promulgated in New Jersey Register February 1, 1993. Class IIA Groundwaters are classified as being potable or convertible to potable use with conventional treatment.

c - Lead action level, relevant to point-of-use, is 15 ug/L.

d - MCL goal.

p - Proposed MCL.

s - Secondary MCL.

q - Technology-based standard (PQL or Practical Quantitation Limit).

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TABLE 2-2

L.E. CARPENTER SITE SPECIFIC GROUNDWATER FOR DISCHARGE CRITERIA

COMPOUND	DISCHARGE CRITERIA
Ethylbenzene	350
Toluene	500
Xylenes (total)	20
Bis(2-Ethylhexyl)phthalate	30
n-Decane	50
Di-n-octylphthalate	50
1-Ethyl-3-methylbenzene	50
n-Nonane	50
1,2,3-Trimethylbenzene	50
1,2,4-Trimethylbenzene	50
1,3,5-Trimethylbenzene	50
Antimony	20
Arsenic	8

TABLE 2-3

L.E. CARPENTER SITE SPECIFIC GROUNDWATER INTERIM DISCHARGE CRITERIA

COMPOUND	DISCHARGE CRITERIA
Organic Compounds	
Chlorobenzene	2
Chloromethane	15
1,1-Dichloroethane	35
1,1-Dichloroethene	2
cis-1,2-Dichloroethene	5
trans-1,2-Dichloroethene	50
Heptane	50
Tetrachloroethene	1
1,1,1-Trichloroethane	15
Trichloroethene	1
1,1,2 Trichloro-1,2,2-trifluoroethane	10,000
Carbon Tetrachloride	2
Acetone	350
Methyl Ethyl Ketone [2-Butanone]	150
Butylbenzylphthalate	50
n-Butylbenzene	50
1,2-Diethylbenzene	50
Diethylphthalate	2500
Di-n-butylphthalate	450
Isopropylbenzene [Cumene]	150
Naphthalene	15
N-Nitrosodiphenylamine	20
1,2,3,4-Tetramethylbenzene	50
Phenol	2000
2-Nitrophenol	50

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TABLE 2-3 (CONT'D)

L.E. CARPENTER SITE SPECIFIC GROUNDWATER INTERIM DISCHARGE CRITERIA

COMPOUND	DISCHARGE CRITERIA
Inorganic Compounds	
Beryllium	20
Cadmium	2
Chromium	50
Copper	500
Lead	10
Mercury	1
Nickel	50
Selenium	10
Zinc	2720

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TABLE 2-4

SURFACE WATER QUALITY CRITERIA

Parameter	Federal Ambient Water Quality Criteria			New Jersey Surface Water Quality Standards
	Human Health, Fish Ingestion Only	Aquatic Toxicity, Freshwater		
		Acute	Chronic	
Arsenic	2.2	850 (pentavalent form)	48 (pentavalent form)	50
Barium	NA	NA	NA	1,000
Calcium	NA	NA	NA	NA
Chromium (trivalent)	170	1,700	210	50*
Chromium (hexavalent)	50	16	11	50*
Iron	NA	1,000	NA	NA
Magnesium	NA	NA	NA	NA
Manganese	NA	NA	NA	NA
Selenium	10	280	36	10
Sodium	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA

NOTES:
Concentrations in ug/L
* - not valence specific
NA - not available

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TABLE 2-5

MAXIMUM CONCENTRATION OF CONTAMINANTS FOR TOXICITY CHARACTERISTIC LEACHATE

PARAMETER*	OBJECTIVES (MG/L)
Arsenic	5.0
Barium	100.0
Benzene	0.5
Cadmium	1.0
Chromium	5.0
1,2-Dichloroethane	0.5
1,1-Dichloroethylene	0.7
Lead	5.0
Mercury	0.2
Methyl Ethyl Ketone	200.0
Selenium	1.0
Silver	5.0
Tetrachloroethylene	0.7
Trichloroethylene	0.5

* List of metals and organics found in soil at L.E. Carpenter for which TCLP maximum concentrations are established.

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TABLE 2-6

NEW JERSEY DRAFT SOIL CLEANUP CRITERIA

Parameter	Surface Soil[a] Standard Residential Use (mg/kg)	Surface Soil[a] Standard Non-Residential Use (mg/kg)	Subsurface Soil Standard (mg/kg)
<u>Organics</u>			
Acetone	1,000	1,000	50
Aroclor 1254 (PCB)	0.49	2.0	100
Benzene	3.0	13	1.0
Bis(2-ethylhexyl)phthalate	49	210	100
Butyl benzyl phthalate	1,100	10,000	100
Di-n-butyl phthalate	5,700	10,000	100
Di-n-octyl phthalate	1,100	10,000	100
Ethylbenzene	1,000	1,000	100
Methylene chloride	49	210	10
Methyl ethyl ketone	1,000	1,000	50
Tetrachloroethene	4.0	6.0	1
Toluene	1,000	1,000	500
Xylenes (total)	410	1,000	10
Acenaphthene	3,400	10,000	100
Anthracene	10,000	10,000	500
Benzo(a)anthracene	0.9	4.0	500
Benzo(a)pyrene	0.66	0.66	100
Benzo(b)fluoranthene	0.9	4.0	500
Benzo(k)fluoranthene	0.9	4.0	500
Benzo(g,h,i)perylene	NS	NS	500
Chrysene	0.9	40	500
Dibenzo(a,h)anthracene	0.66	0.66	500
Fluoranthene	2,300	10,000	500
Fluorene	2,300	10,000	500
Indeno(1,2,3-c,d)pyrene	0.9	4.0	500
Naphthalene	230	4,200	100
Pyrene	1,700	10,000	500

TABLE 2-6 (CONT'D)

NEW JERSEY DRAFT SOIL CLEANUP CRITERIA

Parameter	Surface Soil[a] Standard Residential Use (mg/kg)	Surface Soil[a] Standard Non-Residential Use (mg/kg)	Subsurface Soil Standard (mg/kg)
Metals			
Antimony	14	340	340*
Arsenic	20*	20*	20*
Barium	700	47,000	
Beryllium	1.0	1.0	
Cadmium	1	100	
Copper	600	600	
Lead	100	600	
Mercury	14	270	
Nickel	250	2,400	
Silver	110	4,100	
Thallium	2	2	
Vanadium	370	7,100	
Zinc	1,500	1,500	
Cyanide	1,100	21,000	

a - Surface soil defined as the top two feet of soil.
Numerical subsurface standards have not been proposed for inorganic constituents.
NS - No Standard
* Site specific standard established for L.E. Carpenter

TABLE 2-7

NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS)

Pollutant	Standard	Averaging Period	Regulatory Standard(s)
Sulfur Oxides	Primary Primary Secondary	12-month arith. mean 24-hour average (b) 3-hour average (b)	80 ug/cu. m (0.03 ppm) 365 ug/cu. m (0.14 ppm) 1,300 ug/cu. m (0.5 ppm)
Particulate Matter	Prim. & Sec. Prim. & Sec.	Annual arith. mean 24-hour average	50 ug/cu. m 150 ug/cu. m
Carbon Monoxide	Prim. & Sec. Prim. & Sec.	8-hour average 1-hour average	(10 mg/cu. m) 9 ppm(c) (40 mg/cu. m) 35 ppm(c)
Ozone	Primary Secondary	Max. daily 1-hour avg. 1-hour average	(235 ug/cu. m) 0.12 ppm(d) (235 ug/cu. m) 0.12 ppm(d)
Nitrogen Oxides	Prim. & Sec.	12-month arith. mean	100 ug/cu. m (0.053 ppm)
Lead	Prim. & Sec.	Quarterly mean	1.5 ug/cu. m

NOTES:

(a) National short-term standards are not to be exceeded more than once in a calendar year.
(b) National standards are block averages rather than moving averages.
(c) National secondary standards for carbon monoxide have been dropped.
(d) Maximum daily 1-hour average: averaged over a 2-year period, the expected number of days above the standard must be less than or equal to one.

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TABLE 2-8
SUMMARY OF SELECTED CHEMICAL-SPECIFIC ARARs FOR THE L.E. CARPENTER SITE

PARAMETER	CRITERION	SOURCE
GROUNDWATER		
DEHP	30 ug/L	NJCSCS Class IIA Ground Water Quality Standards
Xylenes	40 ug/L	NJCSCS Class IIA Ground Water Quality Standards
Ethylbenzene	700 ug/L	NJCSCS Class IIA Ground Water Quality Standards
Antimony	20 ug/L	NJCSCS Class IIA Ground Water Quality Standards
Arsenic	8 ug/L	NJCSCS Class IIA Ground Water Quality Standards
SOIL		
DEHP	100 mg/kg	NJCSCS Subsurface proposed Soil Cleanup Standards
Xylenes	10 mg/kg	NJCSCS Subsurface proposed Soil Cleanup Standards
Ethylbenzene	100 mg/kg	NJCSCS Subsurface proposed Soil Cleanup Standards
Lead	600 mg/kg	NJCSCS Nonresidential proposed Soil Cleanup Standards
Antimony	340 mg/kg	NJCSCS Nonresidential proposed Soil Cleanup Standards
Antimony	340 mg/kg	Site Specific Subsurface Soil Cleanup Standards
PCBs	2.0 mg/kg	NJCSCS Nonresidential proposed Soil Cleanup Standards
PCBs	0.45 mg/kg	NJCSCS Residential proposed Soil Cleanup Standards
SOLID WASTE		
DEHP	28 mg/kg	RCRA-CCW compound[a]
Xylene	28 mg/kg	RCRA-CCW compound[a]
Xylene	0.05 mg/L	RCRA-CCWE Wastewaters[b]
Xylene	0.15 mg/L	RCRA-CCWE Non-Wastewaters[b]
Ethylbenzene	0.5 mg/L	RCRA-CCWE Wastewaters[b]
Ethylbenzene	0.53 mg/L	RCRA-CCWE Non-Wastewaters[b]
Arsenic	5 mg/L	RCRA-TCLP[c]
Cadmium	1 mg/L	RCRA-TCLP[c]
Chromium	5 mg/L	RCRA-TCLP[c]
Lead	5 mg/L	RCRA-TCLP[c]
Mercury	0.2 mg/L	RCRA-TCLP[c]

[a] This criterion represents the treatment level required for disposal in a Subtitle C hazardous waste landfill <u>if</u> the solid waste or soil debris is considered to be a listed hazardous waste.
[b] RCRA CCWE criteria are applicable to the contaminant criteria in the waste extract, not the waste itself.
[c] TCLP criteria are applicable to waste extract, not the waste itself.

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TABLE 2-9

POTENTIAL ACTION AND LOCATION-SPECIFIC ARARs AND TBCs FOR THE L.E. CARPENTER SITE

Relevant and Appropriate	To Be Considered
ACTION-SPECIFIC	
RCRA-40 CFR 261, 263, 264, 268*	• EPA document EPA/450/1-90-002
RCRA - 40 CFR 260, 264, 265, 268, 270, 271 - Corrective Action Management Units	• EPA document EPA/450/3-87-017
RVRSA policy prohibiting discharge from groundwater remediations	• Discharge to Surface Water: New Jersey, "Guidelines - Waste Discharge"
NJDEPE DWR Order No. 60-Groundwater Cleanup Criteria	• Required information for discharges to surface waters
NJAC 7:14A-6 - Additional Requirements for Discharges to Groundwater	• Toxic management - regulating point source discharge of toxic substances into NJ waters
NJAC 7:9-4.1 et seq. - Surface Water Quality Standards	• Indirect discharge permitting procedures
NJAC 7:14A - New Jersey Pollutant Discharge Elimination System	• Required pretest protocol
NJAC 7:27 - Air Pollution Control	• Protocol - continuous emission monitors DEQ
NJAC 7:26 - New Jersey Hazardous Waste Regulations	• Guidelines for review of application for toxic substances emissions
NJAC 7:14A-5 - Requirements for Wells Infiltrating Liquid Wastes	• Equipment compliance with NJ Air Pollution Control Regulations
NJAC 7:14A-12 and 13 - Wastewater Treatment Requirements	• Technical Guidance Study EPA/450/4-90-014
NJAC 7:9-9 - Sealing of Abandoned Wells	• Guidance on Ambient Air Monitoring, EPA/450/4-89-015 and EPA/450/4-90-005
NJAC 7:9-7 - Well Installation	• DMR Instruction Manual, NJDEPE 5/91
NJAC 7:26E - Technical Requirements for Site Remediation	• Hazardous Waste Incineration Guidance Series EPA /625/6-86/012, EPA/625/6-89/019, and EPA/625/6-89/021
NJAC 7:9-6 - Ground Water Quality Criteria	• EPA Seminar Publication: Requirements for Hazardous Waste Landfill Design, Construction, and Closure
	• Draft RCRA Guidance Document: Landfill Design, Liner Systems and Final Cover PB87-157657
	• Guidance on Delisting NPL sites, OSWER directive 9320.2 - 3A
	• OSWER Directive 9834.11 - Off-Site Policy
	• OSWER Directive 9234.1-06: Applicability of LDRs to RCRA and CERCLA Groundwater Treatment Reinjection

* Applicable subpart depends on remedial action selected.

TABLE 2-9 (Continued)

POTENTIAL ACTION AND LOCATION-SPECIFIC ARARs AND TBCs FOR THE L.E. CARPENTER SITE

Relevant and Appropriate	To Be Considered
LOCATION-SPECIFIC	
Treatment facility location: • In 100-year Flood Plain - 40 CFR 18 • In Lowlands - Executive Order 11988 • NJAC 7:13 - Flood Hazard Area Regulations • National Historic Preservation Act (16 USC 470) Fish and Wildlife Coordination Act: NJAC 7:7E-3 - Flood Plains, Wetlands, Endangered Species/Habitat NJAC 7:2-11 - Description of Natural Areas of State Wetlands: • Wetlands Act of 1970 (NJSA 13:9A-1) • Freshwater Wetlands Protection Act	New Jersey's threatened plant species list

TABLE 4-1

REMEDIAL TECHNOLOGIES EVALUATED FOR THE L.E. CARPENTER SITE

Environmental Media	General Response Actions	Remedial Technology Types	Process Options
Soil/Sediment	No Action	No Action	
	Institutional Controls	Restricted access	Fencing deed restriction
	Containment	Surface runoff controls	Regrading, drainage ditches, and silt fencing
		Capping/covering/consolidation	Soil, clay, asphalt, concrete, or multimedia liners
	Removal	Excavation	Excavation
	Treatment	Physical treatment	Soil washing, stabilization, supercritical fluid extraction
		Chemical treatment	Wet air oxidation, supercritical water oxidation
		Thermal treatment	On-site incineration, off-site incineration, low-temperature thermal treatment
		Biological treatment	Solid phase treatment/composting, slurry bioremediation
		In-situ treatment	Bioreclamation, soil flushing, in situ volatilization, electromagnetic heating, vitrification
	Disposal	Landfill	On-site, off-site

TABLE 4-1
(Continued)

REMEDIAL TECHNOLOGIES EVALUATED FOR THE L.E. CARPENTER SITE

Environmental Media	General Response Actions	Remedial Technology Types	Process Options
Groundwater	No Action	No Action	Monitoring
	Institutional Controls	Restricted use Alternate water supply Point-of-use treatment	Deed restriction Public water hookup, bottled water Carbon filters
	Containment	Subsurface diversion	Slurry walls, grout injection, sheet piling, electroosmosis
	Collection	Floating product collection	Product recovery wells, interceptor trenches
		Groundwater collection	Extraction wells, interceptor trenches
	Treatment	Physical treatment	Liquid phase separation, air stripping, steam stripping, carbon adsorption, membrane separation, resin adsorption
		Chemical treatment	UV/chemical oxidation, high-energy electron beam
		Biological treatment	Aerobic, anaerobic, spray irrigation, artificial wetland
		In situ treatment	Biodegradation, permeable treatment beds
	Disposal	Groundwater discharge	To POTW, to surface water, to groundwater

Table 4-2

Summary of the Technology Screening for Soil

Remedial Technology	Process Option	Effectiveness	Implementability	Cost
No Action	No Action	Will not significantly reduce the risk to human health or the environment within the foreseeable future	No further implementation required	Minimal
Institutional Controls	Deed & Permitting Restrictions	Effectively limits future-use risk scenario and prevents potential exposure pathways	Implementable	Low
Surface Runoff Controls	Regrading, Drainage Ditches, and Silt Fencing	Reduces soil migration via erosion	Readily implemented	Low capital and O&M
Capping/Covering	Clay, Soil, Asphalt, Concrete, or Multimedia Liners	Prevents exposure to and migration of soil contaminants. Reduces leaching of contaminants to groundwater from percolated rainwater.	Readily implemented (pavement currently covers 42% of the site)	Low to moderate capital and O&M
Excavation	Excavation	Removes contaminated soil	Readily implemented although structures and activity at the site may hinder implementation	Moderate to high capital

Legend: [shaded] = Not considered further.

Table 4-2
(continued)

Remedial Technology	Process Option	Effectiveness	Implementability	Cost
Physical Treatment	Soil Washing	Well-suited for high-permeability soils. A multistage process could extract organics and inorganics. Useful in reducing soil volume for subsequent treatment steps.	Laboratory testing required	Moderate capital and O&M
	Stabilization	Applicable primarily to metals. Not well suited for organic contamination unless proprietary additives are used. Some leaching of contaminants possible. Does not reduce contaminant volume.	Land disposal restrictions may apply. Would require treatability and performance tests.	Moderate capital, low to moderate O&M
	Supercritical Fluid Extraction	Potentially effective for DEHP	Technology in developmental phase. Would require treatability tests.	High capital and O&M
Chemical Treatment	Wet Air Oxidation	Effective only for organics at high concentration	Applicability to soil slurry is unproven. Would require treatability tests.	High capital and O&M
	Supercritical Water Oxidation	Effective only for organics at high concentration	Applicability to soil slurry is unproven. Would require treatability tests.	High capital and O&M
Thermal Treatment	Incineration	Effective destruction of organics. Metals remain in ash.	Mobile/transportable units available. Local opposition to on-site treatment anticipated.	High capital and O&M
	Low-Temperature Thermal Treatment	Effective for volatile organics. Less effective for DEHP.	Pilot tests required to confirm effectiveness.	High capital, moderate O&M

Legend: [shaded] = Not considered further.

Table 4-2
(continued)

Remedial Technology	Process Option	Effectiveness	Implementability	Cost
Biological Treatment	Solid Phase Treatment Composting	Potentially effective for organics. Metals remain in soil.	Space constraints and VOC emissions make it infeasible	Moderate capital, low O&M
	Slurry Bioremediation	Removes readily degradable organics	Laboratory or pilot-scale tests would be required for DEHP	High capital, moderate O&M
In Situ Treatment	In Situ Bioremediation	Effectiveness hinges on oxygen distribution. Native microbes effective in degrading organic contaminants of concern.	Treatability testing performed. No excavation or delisting required.	Moderate capital and O&M
	Soil Flushing	Nonuniform permeability hinders solvent contact.	Contaminant migration needs to be controlled. Can be implemented in combination with insitu bioremediation.	Moderate capital and O&M
	In Situ Volatilization	Not effective for DEHP. Effective for volatiles.	Readily implementable	Moderate capital and O&M
	Electromagnetic Heating	Better semivolatile volatilization than ISV, but not effective for DEHP	Readily implementable. Potential flammability hazard.	High capital and O&M
	In Situ Vitrification	Permeability and nonuniformity of soils impairs vitrification. Stabilizes metals.	Implementable	High capital and O&M

Legend: = Not considered further.

Table 4-2
(continued)

Remedial Technology	Process Option	Effectiveness	Implementability	Cost
Disposal Option	Onsite RCRA Landfill	Isolates contaminants to inhibit leaching. No contaminant reduction.	Space limitations, and land use prohibitions. Future liability.	High capital, low O&M
	Offsite RCRA Landfill	Isolates contaminant to inhibit leaching. No contaminant reduction.	Subject to RCRA restrictions. Future liability.	Low capital, low O&M

Legend: = Not considered further.

Table 4-3

Summary of the Technology Screening for Groundwater and Immiscible Product

Remedial Technology	Process Option	Effectiveness	Implementability	Cost
No Further Action	Monitoring	Would not reduce the extent of contamination	No further implementation required	Minimal
Institutional Controls	Deed Restriction, Public Water Hookup, or Point of Use Treatment	Prevents use of contaminated water. No contaminant reduction.	Readily implemented	Low
Subsurface Diversion	Slurry Walls	Effective in reducing migration of floating product. Bedrock is too deep to form a complete groundwater barrier. Can reduce extraction of clean groundwater.	Readily implemented	Moderate capital, low O&M
	Grout Curtains	This technology has proven to be ineffective in soils with varying permeability.	Readily implemented	Moderate capital, low O&M
	Sheet Piling	Effective in reducing migration of floating product. Bedrock is too deep to form a complete groundwater barrier.	Boulders in the overburden make installation impractical	Moderate capital, low O&M
	Electro-Osmosis	Unclear how floating product would be affected	Unproven technology. Field testing required.	Low to moderate capital, high O&M

Legend: [shaded box] = Not considered further.

Table 4-3
(continued)

Remedial Technology	Process Option	Effectiveness	Implementability	Cost
Collection	Floating Product Recovery	Effectiveness would be increased if used in combination with pump and treat technologies	In operation at the site since May 1984. EIPRS currently operating.	Low incremental capital and O&M
	Extraction	Effective in permeable soils for floating product and groundwater	Extracted groundwater would require treatment and permitting	Moderate capital and O&M
	Interceptor Trenches	Also effective for floating product and shallow groundwater, but less flexible than extraction wells.	Readily implemented	Moderate capital and O&M

Legend: ░░░ = Not considered further.

Table 4-3
(continued)

Remedial Technology	Process Option	Effectiveness	Implementability	Cost
Physical Treatment	Carbon Adsorption	Effective for organics, as long as suspended solids concentrations are not excessive	Readily implemented	Moderate capital, high O&M
	Air Stripping	Effective for VOCs and could be used to reduce total organics mass loading prior to further treatment for DEHP.	Readily implemented. Would require treatment and per-mitting of off gases.	Moderate capital and O&M
	Steam Stripping	Effective for VOCs. Unlikely to be effective for DEHP.	Readily implemented	High capital and O&M
	Membrane Separation	Effective for higher molecular weight compounds and metals. Substantial pretreatment and maintenance requirements. Not durable. Retained only if metals removal becomes necessary.	Membranes subject to fouling and degradation.	High capital and O&M
	Supercritical Fluid Extraction	May be effective for DEHP.	Technology in developmental phase	High capital and O&M
	Resin Adsorption	Can be tailored to inorganics or organics. Not effective for concentrated contaminants. Retained only if metals removal becomes necessary.	Treatability test required	High capital and O&M
	Phase Separation	Effective on water/organic mixtures. Separated products would require further treatment/disposal.	Readily implemented	Low capital and O&M

Legend: [shaded] = Not considered further.

Table 4-3
(continued)

Remedial Technology	Process Option	Effectiveness	Implementability	Cost
Chemical Treatment	Supercritical Water Oxidation	Effective for concentrated organics, some metals, and floating product. Not effective for dilute contaminants.	Treatability test required	Very high capital, high O&M
	Advanced Oxidation	Effective for organics and some metals	Treatability test required	High capital and O&M
	Wet Air Oxidation	Effective for concentrated organics. Not effective for floating product or dilute contaminants.	Treatability test required	High capital and O&M
	High-Energy Electron Beam	Effectiveness similar to other oxidation type treatment. Works for both dilute and concentrated contaminants.	Several years away from commercial availability	High capital and O&M
Biological Treatment	Aerobic	Removes readily degradable organics. Treatability study indicated effective for DEHP, xylenes, and ethylbenzene	Treatability study indicated favorable implementability.	Moderate capital, moderate O&M
	Anaerobic	Removes degradable organics. Susceptible to upsets. Reported to be unsuitable for DEHP.	Laboratory and pilot-scale tests would be required	High capital, moderate O&M
	Spray Irrigation	Removes volatiles and readily degradable organics. No DEHP removal.	Problems with VOC emissions and space constraints	Low capital and O&M
	Artificial Wetland	Removes organics. Not effective for metals or PCBs.	Problems with VOC emissions and space constraints	Low capital and O&M

Legend: [shaded] = Not considered further.

Table 4-3
(continued)

Remedial Technology	Process Option	Effectiveness	Implementability	Cost
In Situ Treatment	In Situ Bioremediation	Similar to aerobic degradation in an activated sludge system. Potentially effective on contaminants sorbed to soil.	Laboratory or pilot-scale tests required. Treatability study indicated favorable implementability.	Moderate capital and O&M
	Permeable Treatment Beds	Effective only for organics in shallow groundwater for short duration	Readily implementable	Moderate capital and O&M
Groundwater Discharge	To Surface Water	Effective. Could use existing outfall to drainage ditch.	Would require pretreatment and permitting procedure	Low
	To POTW	RVRSA not accepting discharge from GW remediations	Would require pretreatment and permitting procedure	Low
	To Groundwater	Tile fields, injection wells, well points, or infiltration galleries would be effective.	Would require pretreatment, and permitting procedure, and demonstration of containment.	Low

Legend: [shaded] = Not considered further.

TABLE 5-1

INITIAL GROUNDWATER TREATMENT INFLUENT CONCENTRATION ESTIMATE
PRODUCT RECOVERY AND CONTAINMENT CASE

Extraction Well**	A	B	C	D	E	Net Influent Estimate
Nearest Sampled Monitoring Well	MW-1	MW-15s	MW-15s/MW-10	MW-10	MW-6/MW-2*	
DEHP	38.5	ND	17,000	34,000	31,004	16,408
Xylene	3,400	ND	60,000	120,000	60,725	54,945
Ethylbenzene	6,850	ND	13,000	26,000	8,026	10,775
Nontarget BN	320	9.4	4,405	8,800	4,668	3,640
Nontarget VO	1,214	ND	2,168	4,337	2,976	2,139
Total BN +VO	42,422	9.4	96,573	193,137	107,399	87,907
Antimony	ND	ND	17.8	35.5	27.4	16.1
Arsenic	ND	ND	10.6	21.3	1.6	6.7
Zinc	455	25	34.3	43.6	63.2	124.2

Concentrations in ug/L.
ND - Not Detected.
* Extraction well roughly equidistant from two sampled wells, concentrations shown on table is average of two sampled wells.
** Extraction wells are denoted A through E from west to east (westernmost well is denoted as A on this table, second westernmost as B, central as C, etc.).
Nontarget BN, nontarget VO are the sum of those compounds detected, but not listed as chemical specific on this table. Only those inorganics detected in the monitoring wells utilized in influent concentration estimate were included in this table.

TABLE 5-2

COMPREHENSIVE SITE ALTERNATIVES

1. No Action

- Existing groundwater monitoring program.
- Operate enhanced product recovery system passively.

2. Institutional Controls

- Expanded groundwater monitoring.
- Operate enhanced product recovery system passively.
- One additional monitoring well on the Air Products Property.
- Deed restrictions.

3. Groundwater Treatment

- All parts of the Institutional Controls alternative.
- Perform groundwater remediation in two phases.
  - Phase I: Active recovery of immiscible product through three caissons and one well. Recirculation of treated groundwater within capture zone.
  - Phase II: Active recovery of groundwater from shallow zone. Recirculate approximately 70 to 80% of biotreated groundwater within capture zone. Discharge remaining 20-30% of biotreated and carbon-polished water to deep aquifer zone.
- Recirculation of a portion of extracted groundwater within capture zone during Phase II.
- Aboveground aerobic biological treatment of shallow groundwater from recovery system.
- Additional treatment of groundwater to be discharged to deep aquifer zone during Phase II by carbon adsorption as required to comply with discharge permits.
- Complete conversion to carbon adsorption when biological treatment becomes ineffective at low contaminant levels.
- Discharge remaining treated groundwater to deep aquifer zone during Phase II.
- Install a soil and vegetative cover over the east site area.
- Excavation or capping of isolated hot spot surface soils not affected by soil cover. Treatment/disposal of these soils will be consistent with waste classification analytical results.

* Note: Three caissons and one well for extraction of groundwater and four wells recirculation of groundwater during Phase I were indicated during conceptual groundwater modelling. Six extraction wells, one discharge well and five recirculation wells for Phase II were indicated during conceptual groundwater modelling. The actual number and location of extraction, recirculation and discharge wells will be determination during Remedial Design.

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TABLE 5-2

COMPREHENSIVE SITE ALTERNATIVES
(Continued)

4. Groundwater Treatment with Reinfiltration

- All parts of Institutional Controls Alternative.
- Perform groundwater remediation in two phases.
  - Phase I: Active recovery of immiscible product through caissons and one well. Recirculation of treated groundwater within capture zone.
  - Phase II: Active recovery of shallow groundwater zone. Disposition of water to three aquifer regions.
    1. Recycle approximately 10 to 15% of water within CAMU above clay.
    2. Recirculate approximately 70 to 80% of extracted water within capture zone.
    3. Discharge approximately 10 to 15% of water to deep aquifer zone.
- Aboveground aerobic biological treatment of shallow groundwater from recovery system (Phase II).
- Additional treatment of groundwater to be discharged to deep aquifer zone by carbon polishing (Phase II).
- Complete conversion to carbon adsorption when biological treatment becomes ineffective at low contaminant levels.
- Consolidation of organic contaminated soils to within groundwater infiltration area.
- Excavation and off site disposal (consistent with waste classification results) of fill in waste disposal area and PCB contaminated soils located on Wharton Enterprises Property.

* Note: Three caissons and one well for extraction of groundwater and four wells recirculation of groundwater during Phase I were indicated during conceptual groundwater modelling. Six extraction wells, one discharge well and five recirculation wells for Phase II were indicated during conceptual groundwater modelling. The actual number and location of extraction, recirculation and discharge wells will be determination during Remedial Design.

5. Excavation/On-Site Soil Washing/Bioslurry Treatment

- All parts of Alternative 3 (except soil cover for east site).
- Pave starch drying beds (staging and equipment area).
- Excavate, treat (as necessary), and dispose of waste disposal area fill.
- Excavate and wash contaminated soils to separate coarses (clean sand, gravel, and boulders) from fines (contaminated clays and silts).
- On-site backfilling of the clean coarse fraction.
- Treat fines in a bioslurry reactor. Treat wash water by aerobic biological treatment.

TABLE 5-2

COMPREHENSIVE SITE ALTERNATIVES
(Continued)

6. Excavation/Thermal Treatment

- All parts of Alternative 3 (except soil cover for east site).
- Pave starch drying beds for staging and equipment area (Alternative 6A, On-Site Incineration).
- Excavate, treat (as necessary), and dispose of isolated hot spot soils.
- Excavate and incinerate, DEHP-contaminated soils either onsite (Alternative 6A) or offsite (Alternative 6B).
- Backfill site with clean fill.

TABLE 6-1

ALTERNATIVE 1 - NO ACTION

CAPITAL	COST ($1,000's)
TOTAL ESTIMATED CAPITAL COST	0
OPERATING AND MAINTENANCE	**COST ($1,000/YEAR) (YEAR 0-30)**
QUARTERLY GROUNDWATER MONITORING (SAMPLING AND ANALYSIS)	40
SKIMMER O&M	11
IMMISCIBLE PRODUCT DISPOSAL	28
TOTAL ESTIMATED ANNUAL O&M COST	79
PRESENT WORTH O&M COST (5% int.)	1,215
TOTAL ESTIMATED PROJECT COST	**1,215**

Costs are accurate in the range of +50 percent to -30 percent, as specified in the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988).

TABLE 6-2

ALTERNATIVE 2 - INSTITUTIONAL CONTROLS

CAPITAL	COST ($1,000's)
DEED NOTATION & LAND/GROUNDWATER USE RESTRICTIONS (LEGAL FEES)	35
ADDITIONAL MONITORING WELL	5
CONTINGENCY (25% all costs)	10
TOTAL ESTIMATED CAPITAL COST	50
OPERATING AND MAINTENANCE	**COST ($1,000/YEAR) (YEAR 0-30)**
GROUNDWATER MONITORING	48
SKIMMER O&M	11
IMMISCIBLE PRODUCT DISPOSAL	28
FENCING MAINTENANCE	3
TOTAL ESTIMATED ANNUAL O&M COST	90
PRESENT WORTH O&M COST (5% int.)	1,384
TOTAL ESTIMATED PROJECT COST	**1,434**

Costs are accurate in the range of +50 percent to -30 percent, as specified in the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988).

TABLE 6-3

ALTERNATIVE 3 - GROUNDWATER TREATMENT

CAPITAL	COST ($1,000's)		
DEED NOTATION & LAND USE RESTRICTIONS	35		
ADDITIONAL MONITORING/EXTRACTION WELLS (PHASE I)	100		
ADDITIONAL EXTRACTION/RECHARGE WELLS (PHASE II)	220		
TREATABILITY TESTING	100		
PERMIT APPLICATION (AIR & WATER DISCHARGE)	60		
GROUNDWATER TREATMENT SYSTEM	443		
SOIL COVER FOR EAST SITE AREA	99		
HOT SPOT EXCAVATION	25		
HOT SPOT TRANSPORTATION AND DISPOSAL	2,305		
SUBTOTAL	3,387		
ENGINEERING & CONSTRUCTION MANAGEMENT (25%) MOBILIZATION/DEMOBILIZATION/SITE SERVICES (10%) CONTINGENCY (25% all costs)	847 339 1,143		
TOTAL ESTIMATED CAPITAL COST	5,716		
OPERATING AND MAINTENANCE	TIME PERIOD		
	Phase I YR 0-3	Phase II YR 4-10	Phase II YR 11-30
FENCING MAINTENANCE	3	3	3
GROUNDWATER MONITORING	44	44	57
IMMISCIBLE PRODUCT DISPOSAL	27	0	0
EXTRACTION/RECHARGE SYSTEM O&M	11	54	54
GROUNDWATER TREATMENT O&M	77	77	20
TREATMENT CHEMICALS AND CARBON REPLACEMENT	0	70	50
DISCHARGE COMPLIANCE (MONITORING, ETC.)	0	11	11
TOTAL ESTIMATED ANNUAL O&M COST	162	259	195
PRESENT WORTH O&M COST (5% int.)	441	1,295	1,492
TOTAL ESTIMATED PROJECT COST	**8,944**		

Costs are accurate in the range of +50 percent to -30 percent, as specified in the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988). See text for a discussion of assumptions affecting costs.

TABLE 6-4

ALTERNATIVE 4 - GROUNDWATER TREATMENT WITH REINFILTRATION

CAPITAL	COST ($1,000's)		
CAPITAL COST SUBTOTAL FROM ALTERNATIVE 3	3,387		
ADDITIONAL HOT SPOT WASTE EXCAVATION	32		
ADDITIONAL HOT SPOT WASTE TRANSPORTATION/DISPOSAL	1,041		
NUTRIENT/HYDROGEN PEROXIDE ADDITION SYSTEM	42		
REINFILTRATION NETWORK (ASSOCIATED WITH CAMU)	497		
PERMIT APPLICATION (DISCHARGE TO GROUNDWATER)	10		
SUBTOTAL	5,009		
ENGINEERING & CONSTRUCTION MANAGEMENT (25%) MOBILIZATION/DEMOBILIZATION/SITE SERVICES (10%) CONTINGENCY (25% all costs)	1,252 501 1,690		
TOTAL ESTIMATED CAPITAL COST	8,452		
OPERATING AND MAINTENANCE	**TIME PERIOD**		
	PHASE I YR 0-3	**PHASE II YR 4-6**	**PHASE II YR 7-20**
FENCING MAINTENANCE	3	3	3
GROUNDWATER MONITORING	44	44	57
EXTRACTION/RECHARGE SYSTEM O&M	11	54	54
REINFILTRATION SYSTEM O&M	0	35	35
IMMISCIBLE PRODUCT DISPOSAL	27	0	0
GROUNDWATER TREATMENT O&M	77	77	20
TREATMENT CHEMICALS AND CARBON REPLACEMENT	0	40	25
DISCHARGE COMPLIANCE (MONITORING, ETC.)	0	11	11
TOTAL ESTIMATED ANNUAL O&M COST	162	264	205
PRESENT WORTH O&M COST (5% int.)	441	621	1,514
TOTAL ESTIMATED PROJECT COST	**11,028**		

Costs are accurate in the range of +50 percent to -30 percent, as specified in the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988). See text for discussion of assumptions affecting costs.

TABLE 6-5

ALTERNATIVE 5 -EXCAVATION/ON-SITE SOIL WASHING/BIOSLURRY TREATMENT

CAPITAL	COST ($1,000's)		
DEED NOTATION & LAND USE RESTRICTIONS	35		
TREATABILITY TESTING (INCLUDING PUMP TEST)	360		
PERMIT APPLICATION (AIR & WATER DISCHARGE)	70		
ADDITIONAL EXTRACTION	100		
GROUNDWATER/WASHWATER TREATMENT SYSTEM	565		
EXCAVATION	485		
ON-SITE LABORATORY	320		
PAVING FOR STAGING/EQUIPMENT AREA	100		
DISPOSAL AREA WASTE TRANSPORT/INCINERATION	1,041		
BULK MATERIAL TREATMENT AND DISPOSAL	8,300 to 15,600		
SITE RESTORATION (BACKFILL/GRADING, ETC.)	180		
REINSTALLATION OF GROUNDWATER EXTRACTION SYSTEM PHASE II GW SYSTEM	220		
SUBTOTAL	11,776 to 19,076		
ENGINEERING & CONSTRUCTION MANAGEMENT (25%) MOBILIZATION/DEMOBILIZATION/SITE SERVICES (10%) CONTINGENCY (25% all costs)	2,944 to 4,796 1,178 to 1,908 3,978 to 6,438		
TOTAL ESTIMATED CAPITAL COST	19,876 to 32,191		
OPERATING AND MAINTENANCE	TIME PERIOD		
	Phase I YR 0-3	Phase II YR 4-6	Phase II YR 7-20
FENCING MAINTENANCE	3	3	3
GROUNDWATER MONITORING	44	44	57
IMMISCIBLE PRODUCT DISPOSAL	27	0	0
EXTRACTION/RECHARGE SYSTEM O&M	11	54	54
GROUNDWATER TREATMENT O&M	77	77	20
TREATMENT CHEMICALS AND CARBON REPLACEMENT	0	70	50
DISCHARGE COMPLIANCE (MONITORING, ETC.)	0	11	11
TOTAL ESTIMATED ANNUAL O&M COST	162	259	195
PRESENT WORTH O&M COST (5% int.)	441	609	1,440
TOTAL ESTIMATED PROJECT COST	**22,366 to 34,681**		

Costs are accurate in the range of +50 percent to -30 percent, as specified in the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988). See text for discussion of assumptions affecting costs.

TABLE 6-6

ALTERNATIVE 6A - EXCAVATION/THERMAL TREATMENT (ON-SITE INCINERATION)

CAPITAL	COST ($1,000's)		
DEED NOTATION & LAND USE RESTRICTIONS	35		
GROUNDWATER TREATABILITY TEST	100		
ADDITIONAL MONITORING WELL/EXTRACTION TRENCH PHASE I	100		
GROUNDWATER TREATMENT SYSTEM	425		
REPLACEMENT GROUNDWATER EXTRACTION WELLS (6) PHASE II	220		
PERMIT APPLICATION (WATER DISCHARGE & RECHARGE)	20		
EXCAVATION	485		
PAVING FOR STAGING/EQUIPMENT AREA	220		
ON-SITE LABORATORY	1,000		
INCINERATOR PERMITTING (INCLUDING TRIAL BURN)	2,000		
THERMAL TREATMENT	21,263		
SITE RESTORATION (BACKFILL/GRADING)	201		
SUBTOTAL	26,069		
ENGINEERING & CONSTRUCTION MANAGEMENT (25%) MOBILIZATION/DEMOBILIZATION/SITE SERVICES (10%) CONTINGENCY (25% all costs)	6,517 2,607 8,798		
TOTAL ESTIMATED CAPITAL COST	43,991		
OPERATING AND MAINTENANCE	TIME PERIOD		
	Phase I YR 0-3	Phase II YR 4-6	Phase II YR 7-20
FENCING MAINTENANCE	3	3	3
GROUNDWATER MONITORING	44	44	57
IMMISCIBLE PRODUCT DISPOSAL	27	0	0
EXTRACTION/RECHARGE SYSTEM O&M	11	54	54
GROUNDWATER TREATMENT O&M	77	77	20
TREATMENT CHEMICALS AND CARBON REPLACEMENT	0	70	50
DISCHARGE COMPLIANCE (MONITORING, ETC.)	0	11	11
TOTAL ESTIMATED ANNUAL O&M COST	162	259	195
PRESENT WORTH O&M COST (5% int.)	441	609	1,440
TOTAL ESTIMATED PROJECT COST	**46,481**		

Costs are accurate in the range of +50 percent to -30 percent, as specified in the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988). See text for discussion of assumptions affecting costs.

TABLE 6-7

ALTERNATIVE 6B - EXCAVATION/THERMAL TREATMENT (OFF-SITE INCINERATION)

CAPITAL	COST ($1,000's)		
DEED NOTATION & LAND USE RESTRICTIONS	35		
GROUNDWATER TREATABILITY TEST (INCLUDING PUMP TEST)	100		
GROUNDWATER TREATMENT SYSTEM	425		
ADDITIONAL MONITORING WELL/EXTRACTION TRENCH PHASE I WELLS	100		
REPLACEMENT GROUNDWATER EXTRACTION WELLS (6) PHASE II WELLS	220		
PERMIT APPLICATION (WATER DISCHARGE & RECHARGE)	20		
EXCAVATION	485		
WASTE CHARACTERIZATION ANALYSIS	54		
PAVING FOR STAGING/EQUIPMENT AREA	110		
TRANSPORTATION OF SOIL TO INCINERATOR	3,938		
OFF-SITE THERMAL TREATMENT	61,425		
SITE RESTORATION (BACKFILL/GRADING, ETC.)	487		
SUBTOTAL	67,399		
ENGINEERING & CONSTRUCTION MANAGEMENT (25%) MOBILIZATION/DEMOBILIZATION/SITE SERVICES (10%) CONTINGENCY (25% all costs)	509 204 17,028		
TOTAL ESTIMATED CAPITAL COST	85,140		
OPERATING AND MAINTENANCE	TIME PERIOD		
	Phase I YR 0-3	Phase II YR 4-6	Phase II YR 7-20
FENCING MAINTENANCE	3	3	3
GROUNDWATER MONITORING	44	44	57
IMMISCIBLE PRODUCT DISPOSAL	27	0	0
EXTRACTION/RECHARGE SYSTEM O&M	11	54	54
GROUNDWATER TREATMENT O&M	77	77	20
TREATMENT CHEMICALS AND CARBON REPLACEMENT	0	70	50
DISCHARGE COMPLIANCE (MONITORING, ETC.)	0	11	11
TOTAL ESTIMATED ANNUAL O&M COST	162	259	195
PRESENT WORTH O&M COST (5% int.)	441	609	1,440
TOTAL ESTIMATED PROJECT COST	**87,630**		

Costs are accurate in the range of +50 percent to -30 percent, as specified in the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988). See text for discussion of assumptions affecting costs.

TABLE 6-8

ARARs COMPLIANCE SUMMARY

	1 No Action	2 Institutional Controls	3 Groundwater Treatment	4 Groundwater Treatment with Reinfiltration	5 Excavation/On-Site Soil Washing/Bioslurry Treatment	6 Excavation/ Thermal Treatment
Chemical-Specific						
Groundwater	MCLs and NJ Class II-A cleanup standards[a] exceeded	MCLs and NJ Class II-A cleanup standards exceeded	Expected to meet	Expected to meet	Expected to meet	Expected to meet
Soil	New Jersey draft cleanup criteria[a] exceeded	New Jersey draft cleanup criteria exceeded	New Jersey proposed cleanup standards exceeded	Expected to meet	Expected to meet	Expected to meet
RCRA Toxicity Characteristic (Treated Soil, Used Carbon)	NA	NA	NA	Expected to meet	Expected to meet Coarse soil may require additional treatment	Expected to meet
Action-Specific						
Clean Closure (40 CFR 264.111)	NA	NA	NA	Will meet	Will meet	Will meet
Closure with Waste in Place (40 CFR 264.228)	Will not meet	Will not meet	Will not meet	NA	NA	NA
Solid Waste Disposal (40 CFR 241.200-212)	NA	NA	Will meet (disposal of used activated carbon)	NA	See Alternative 3	Nonhazardous residuals will be disposed off site/on site dependent on analyses.

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[a] New Jersey draft cleanup criteria are not ARARs but are TBCs.

TABLE 6-8

ARARs COMPLIANCE SUMMARY
(Continued)

	1 No Action	2 Institutional Controls	3 Groundwater Treatment	4 Groundwater Treatment with Reinfiltration	5 Excavation/On-Site Soil Washing/Bioslurry Treatment	6 Excavation/ Thermal Treatment
NPDES (40 CFR 122-125) and NJPDES NJAC 7:9-4.1 et seq. and NJAC 7:15 A-5)	NA	NA	Permit requirements for surface water discharge will be fulfilled.	Permit requirements for groundwater/ surface water discharge will be fulfilled.	See Alternative 3	See Alternative 3
Ambient Water Quality Standards (CWA 402 (a)(1))	NA	NA	Compliance will occur by meeting NPDES limitations	See Alternative 3	See Alternative 3	See Alternative 3
Air Emissions (from Excavations) (NJAC 7:27-16)	NA	NA	NA	NA	Will meet	Will meet
Location-Specific						
RCRA Location of TSD Facility in 100-Year Floodplain (40 CFR 264.18)	NA	NA	Will meet	Will meet	Will meet	Will meet
Floodplain Management - Evaluate Potential Effects of Actions, Avoid Adverse Impacts (40 CFR 6, App. A)	NA	NA	Will meet	Will meet	May require exemption for low-lying area near Wharton Enterprises.	See Alternative 5
State Siting Standard for New Incineration	NA	NA	NA	NA	NA	Expected to meet substantive requirements

TABLE 6-9

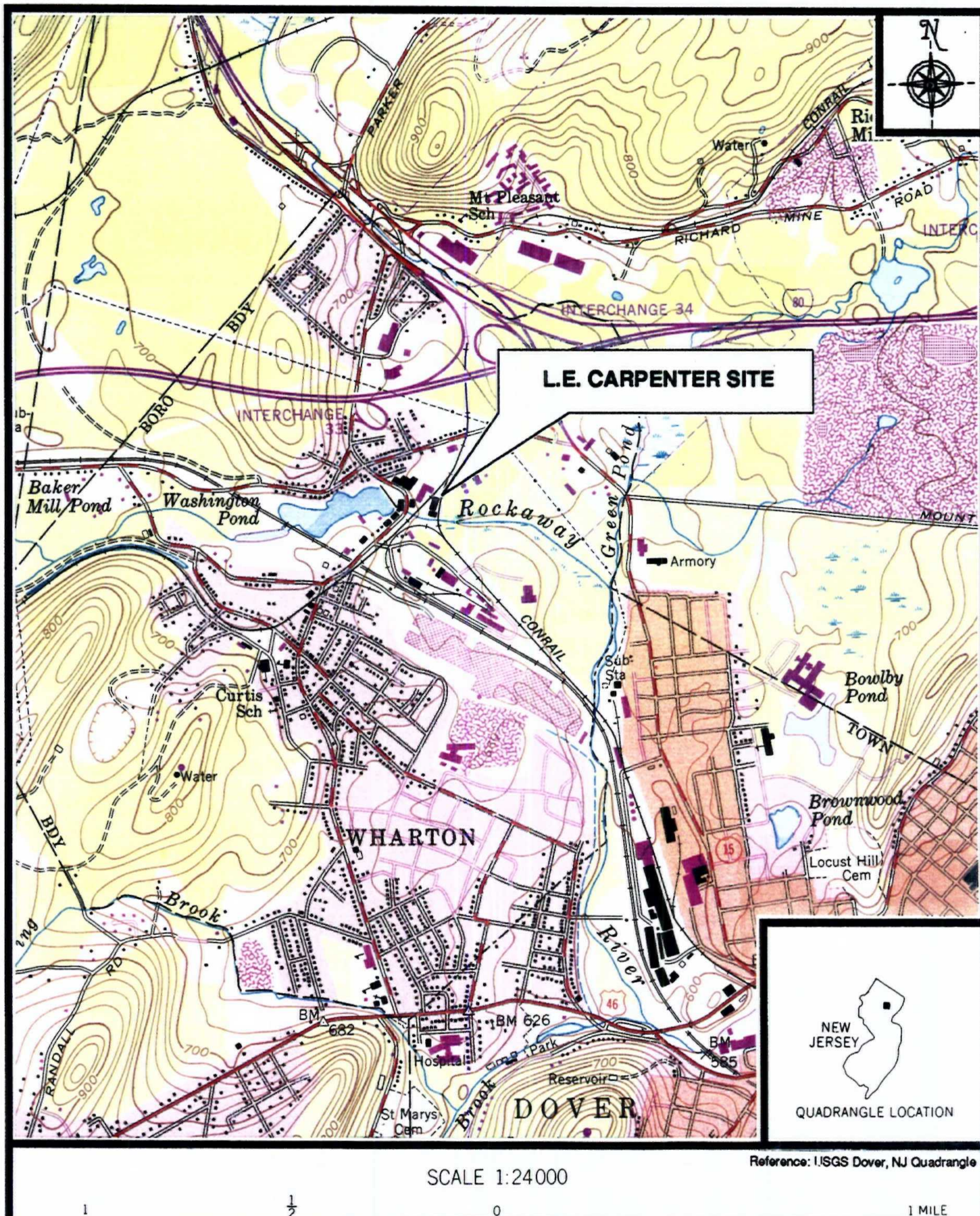
COMPARATIVE ANALYSIS OF ALTERNATIVES

Alternative	Protection of Human Health and Environment	Compliance with ARARS	Long-Term Effectiveness and Permanence	Reduction in Toxicity, Mobility, Volume	Short-Term Effectiveness	Implement-ability	Estimated Present Worth Cost (Millions)
1. No Action	-	-	-	-	NA	NA	1.21
2. Institutional Controls	-	-	-	-	+	+	1.43
3. Groundwater Treatment	o	o[a]	o	o	o	+	8.94
4. Groundwater Treatment with Reinfiltration	o	o	+	+	o	o	11.0
5. Excavation/On-site Soil Washing/Bioslurry Treatment	o	o	+	+	-	-	22.4 to 34.7
6A. Excavation/Thermal Treatment (On-site Incineration)	o	o	+	+	-	-	46.5
6B. Excavation/Thermal Treatment (Off-site Incineration)	o	o	+	+	-	-	87.6

Notes: + = Exceeds evaluation criterion
o = Meets evaluation criterion
- = Does not meet and/or major limitations associated with evaluation criterion
[a] = Meets ARARs, but does not meet proposed New Jersey soil cleanup standards, which are TBCs.
Costs for Alternatives 3, 4, 5 and 6 assume use of biological treatment for groundwater treatment.
Costs are accurate in the range of +50 percent and -30 percent.

APPENDIX B

FIGURES



WESTON
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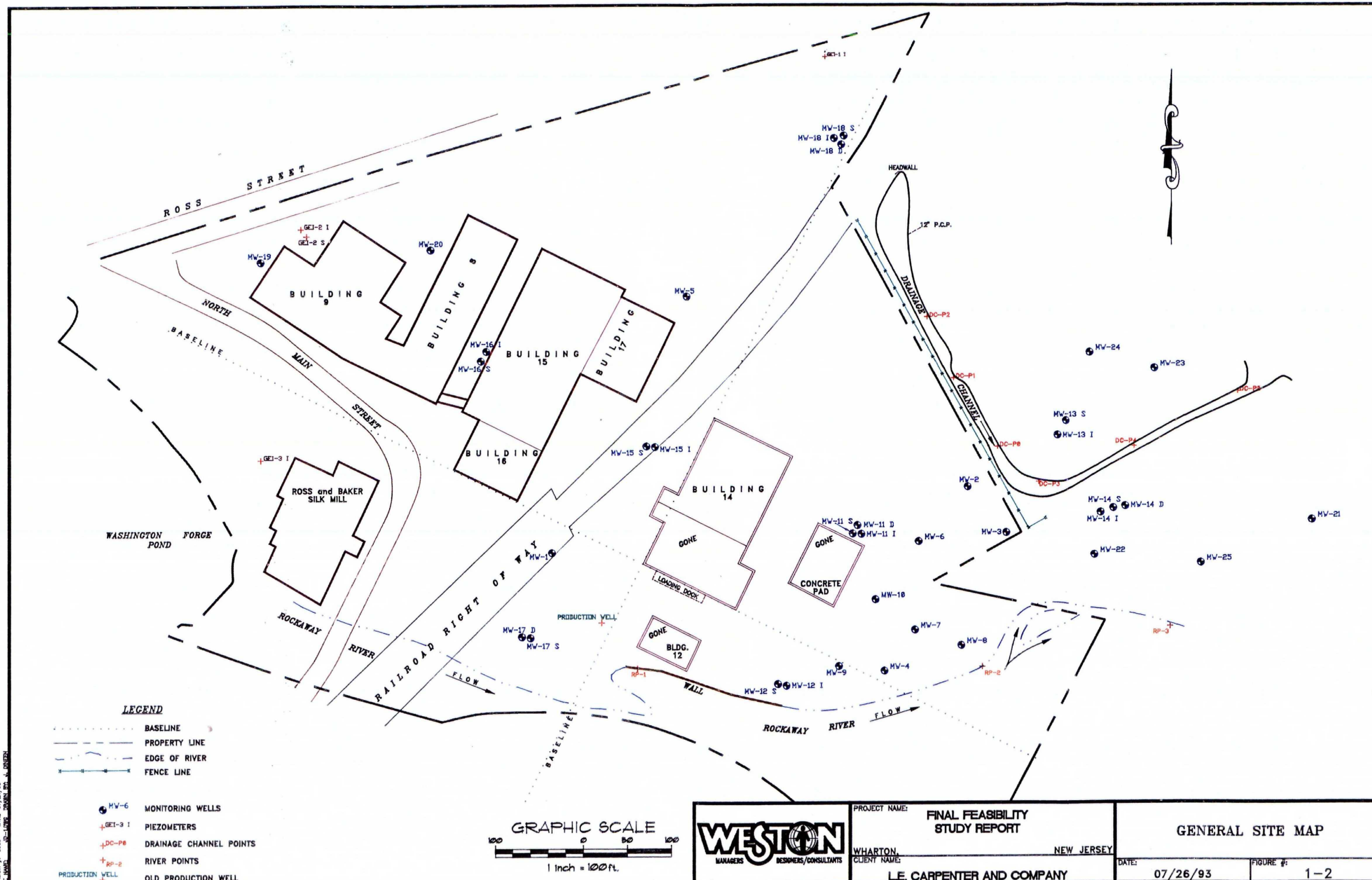
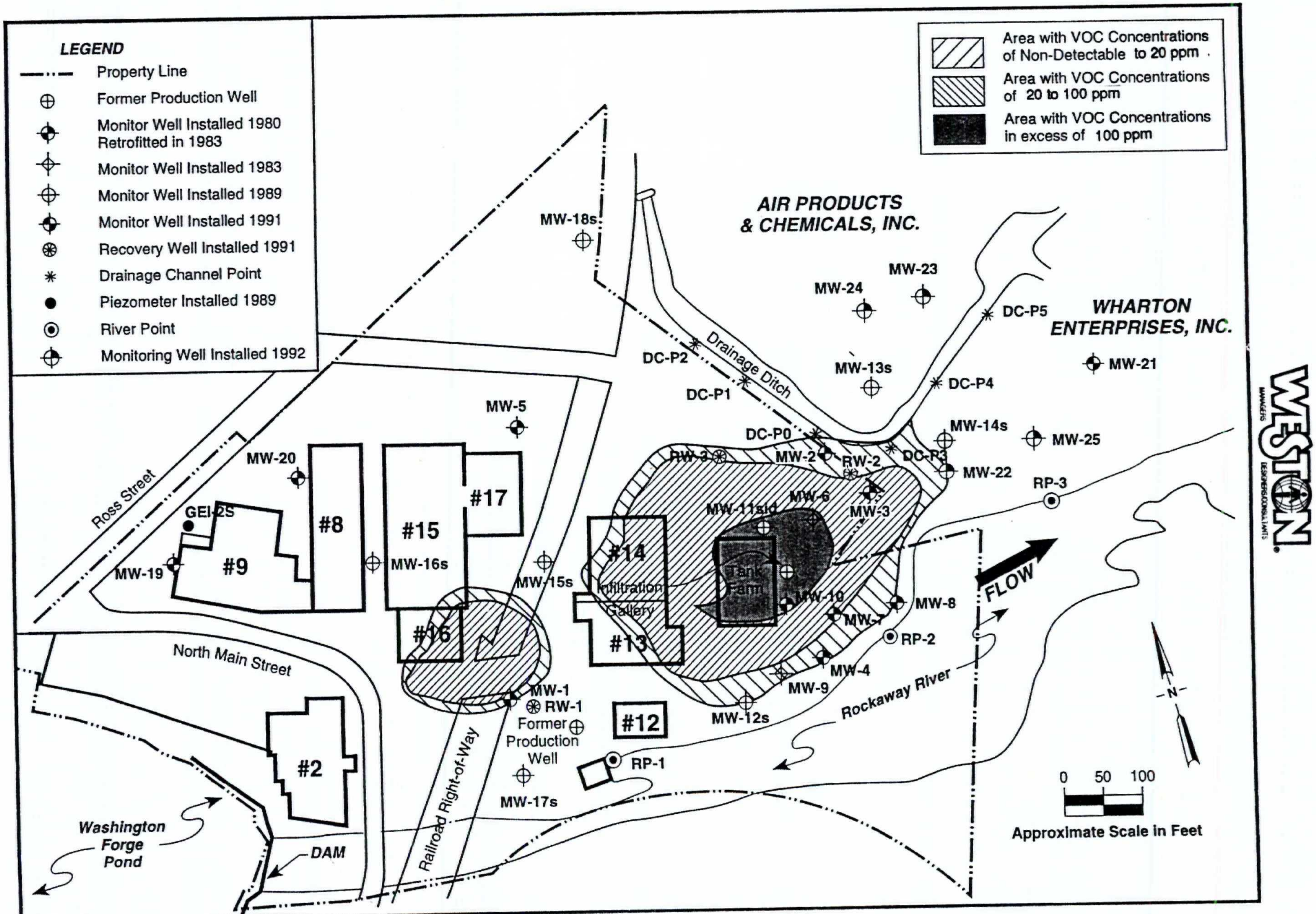
L.E. CARPENTER SITE
WHARTON, NJ.

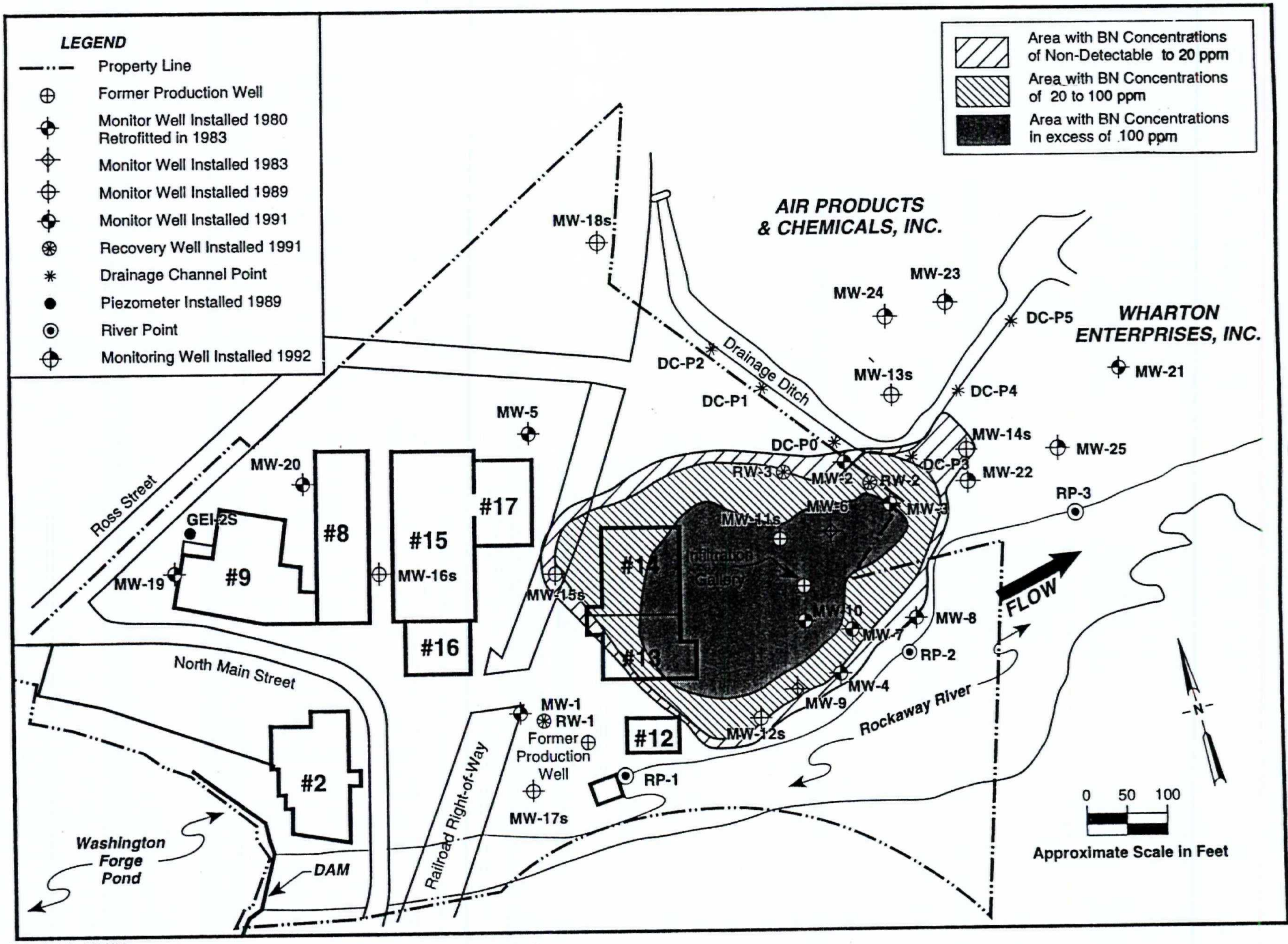
FIGURE 1-1
SITE LOCATION MAP


ROSS STREET
NORTH MAIN STREET
BASELINE
BUILDING 9
BUILDING 8
BUILDING 15
BUILDING 17
BUILDING 16
BUILDING 14
ROSS and BAKER SILK MILL
WASHINGTON FORGE POND
ROCKAWAY RIVER
RAILROAD RIGHT OF WAY
GONE
LOADING DOCK
CONCRETE PAD
BLDG. 12
WALL
FLOW
PRODUCTION WELL
HEADWALL
12" P.C.P.
DRAINAGE CHANNEL
GEI-1 I
GEI-2 I
GEI-2 S
GEI-3 I
MW-1
MW-2
MW-3
MW-4
MW-5
MW-6
MW-7
MW-8
MW-9
MW-10
MW-11 S
MW-11 D
MW-11 I
MW-12 S
MW-12 I
MW-13 S
MW-13 I
MW-14 S
MW-14 D
MW-14 I
MW-15 S
MW-15 I
MW-16 I
MW-16 S
MW-17 D
MW-17 S
MW-18 S
MW-18 I
MW-18 D
MW-19
MW-20
MW-21
MW-22
MW-23
MW-24
MW-25
DC-P0
DC-P1
DC-P2
DC-P3
DC-P4
DC-P5
RP-1
RP-2
RP-3
LEGEND
BASELINE
PROPERTY LINE
EDGE OF RIVER
FENCE LINE
MW-6 MONITORING WELLS
GEI-3 I PIEZOMETERS
DC-P0 DRAINAGE CHANNEL POINTS
RP-2 RIVER POINTS
PRODUCTION WELL OLD PRODUCTION WELL
GRAPHIC SCALE
100 0 50 100
1 inch = 100 ft.
WESTON
MANAGERS DESIGNERS/CONSULTANTS
PROJECT NAME:
FINAL FEASIBILITY STUDY REPORT
WHARTON, NEW JERSEY
CLIENT NAME:
L.E. CARPENTER AND COMPANY
GENERAL SITE MAP
DATE: 07/26/93
FIGURE #: 1-2



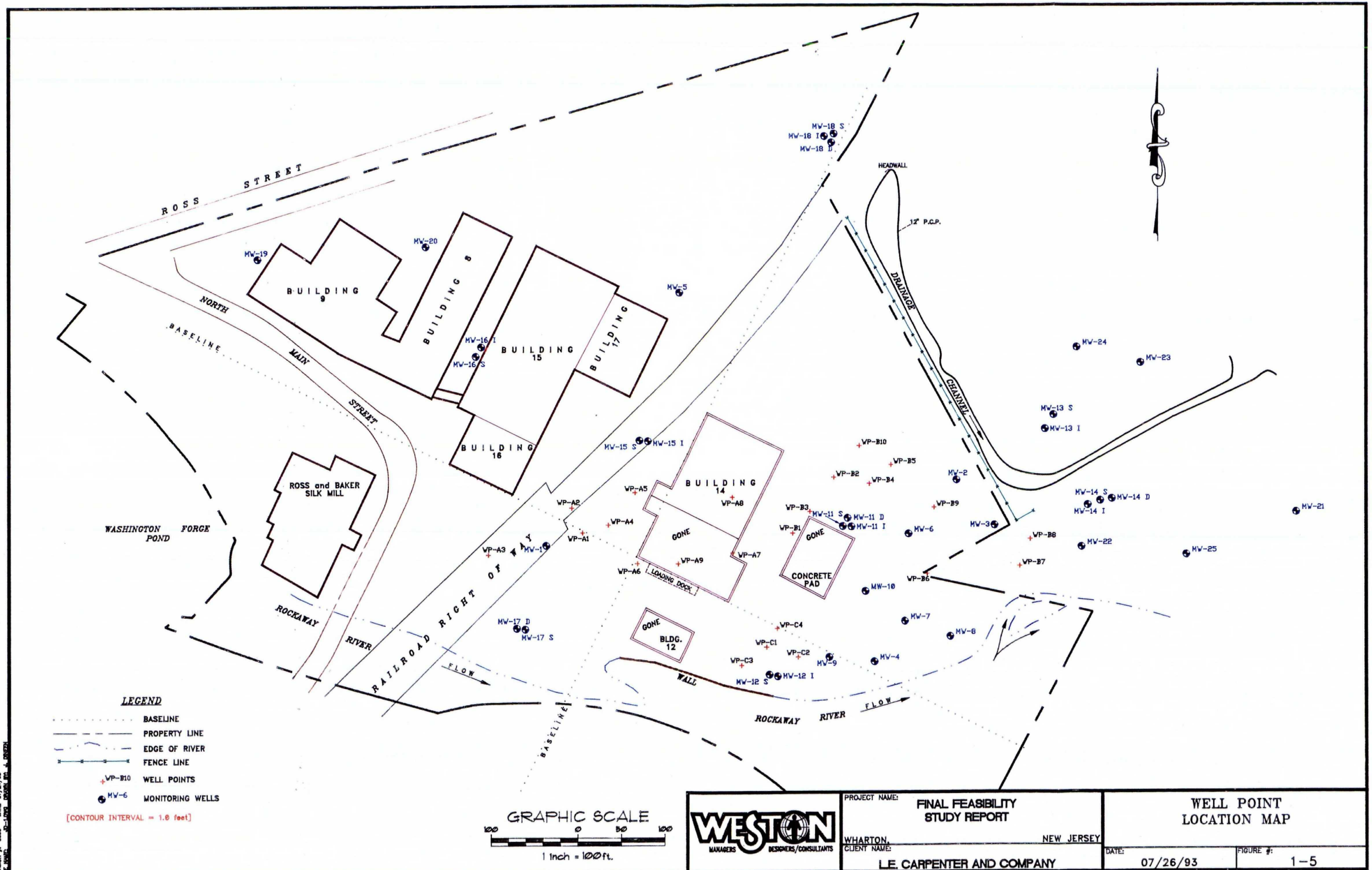
1102-8244a 7/15/92

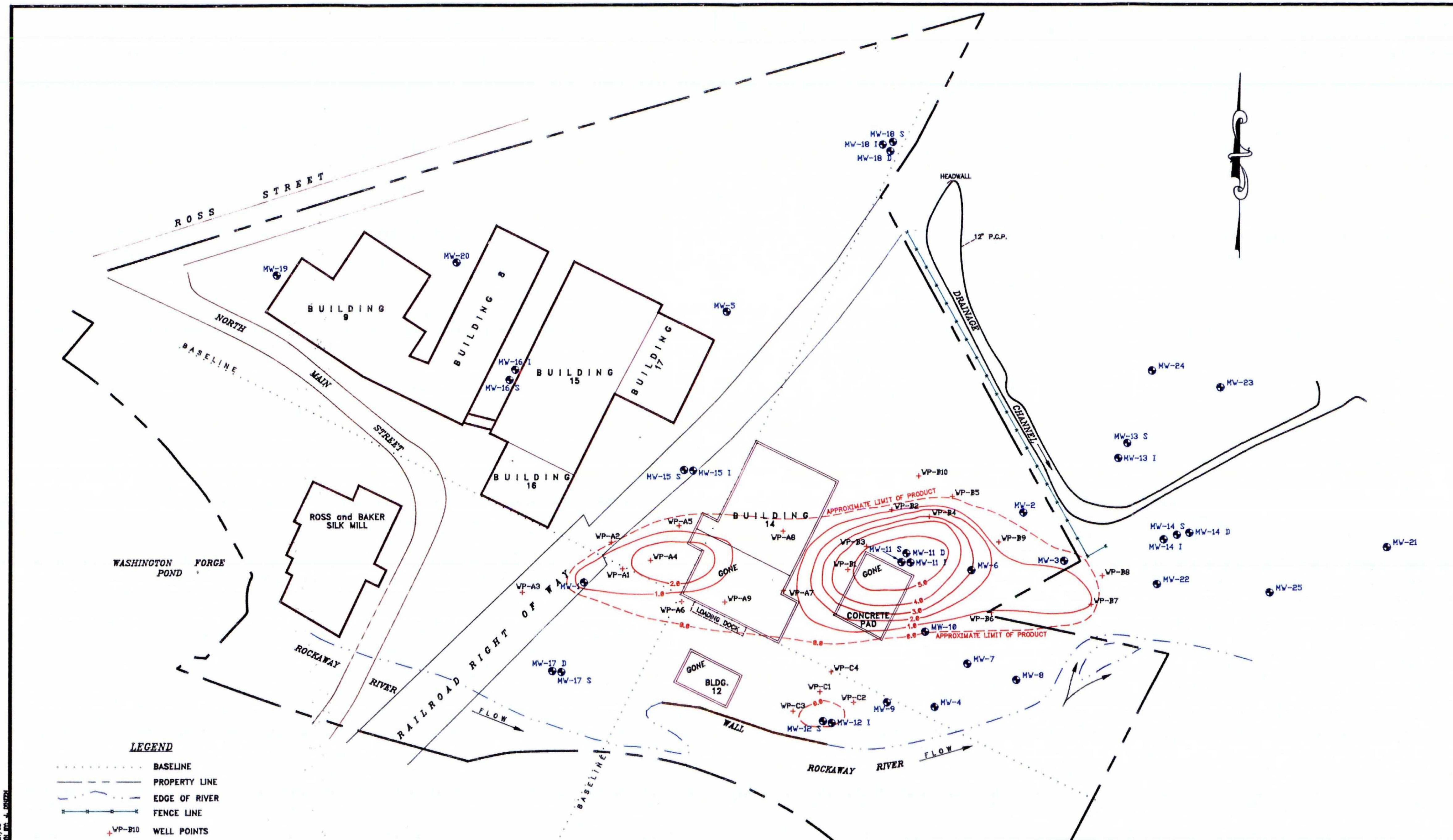
FIGURE 1-3 AREAL EXTENT OF DISSOLVED VOC IN THE SHALLOW AQUIFER ZONE L.E. CARPENTER AND COMPANY, WHARTON, NEW JERSEY



1102-8244b 7/14/92

FIGURE 1-4 AREAL EXTENT OF DISSOLVED BN COMPOUNDS IN THE SHALLOW AQUIFER ZONE L.E. CARPENTER AND COMPANY, WHARTON, NEW JERSEY


ROSS STREET
NORTH MAIN STREET
BASELINE
BUILDING 9
BUILDING 8
BUILDING 15
BUILDING 17
BUILDING 16
BUILDING 14
BLDG. 12
GONE
CONCRETE PAD
LOADING DOCK
ROSS and BAKER SILK MILL
WASHINGTON FORGE POND
ROCKAWAY RIVER
FLOW
RAILROAD RIGHT OF WAY
WALL
HEADWALL
12" P.C.P.
DRAINAGE CHANNEL
MW-18 S
MW-18 I
MW-18 D
MW-19
MW-20
MW-5
MW-16 I
MW-16 S
MW-15 S
MW-15 I
MW-1
MW-17 D
MW-17 S
MW-24
MW-23
MW-13 S
MW-13 I
MW-2
MW-14 S
MW-14 D
MW-14 I
MW-21
MW-11 S
MW-11 D
MW-11 I
MW-6
MW-3
MW-22
MW-25
MW-10
MW-7
MW-8
MW-9
MW-4
MW-12 S
MW-12 I
WP-A1
WP-A2
WP-A3
WP-A4
WP-A5
WP-A6
WP-A7
WP-A8
WP-A9
WP-B1
WP-B2
WP-B3
WP-B4
WP-B5
WP-B6
WP-B7
WP-B8
WP-B9
WP-B10
WP-C1
WP-C2
WP-C3
WP-C4
LEGEND
BASELINE
PROPERTY LINE
EDGE OF RIVER
FENCE LINE
WP-B10 WELL POINTS
MW-6 MONITORING WELLS
[CONTOUR INTERVAL = 1.0 feet]
GRAPHIC SCALE
100 0 50 100
1 inch = 100 ft.
WESTON
MANAGERS DESIGNERS/CONSULTANTS
PROJECT NAME:
FINAL FEASIBILITY STUDY REPORT
WHARTON, NEW JERSEY
CLIENT NAME:
L.E. CARPENTER AND COMPANY
WELL POINT LOCATION MAP
DATE: 07/26/93
FIGURE #: 1-5



WESTON
MANAGERS DESIGNERS/CONSULTANTS

PROJECT NAME: FINAL FEASIBILITY STUDY REPORT

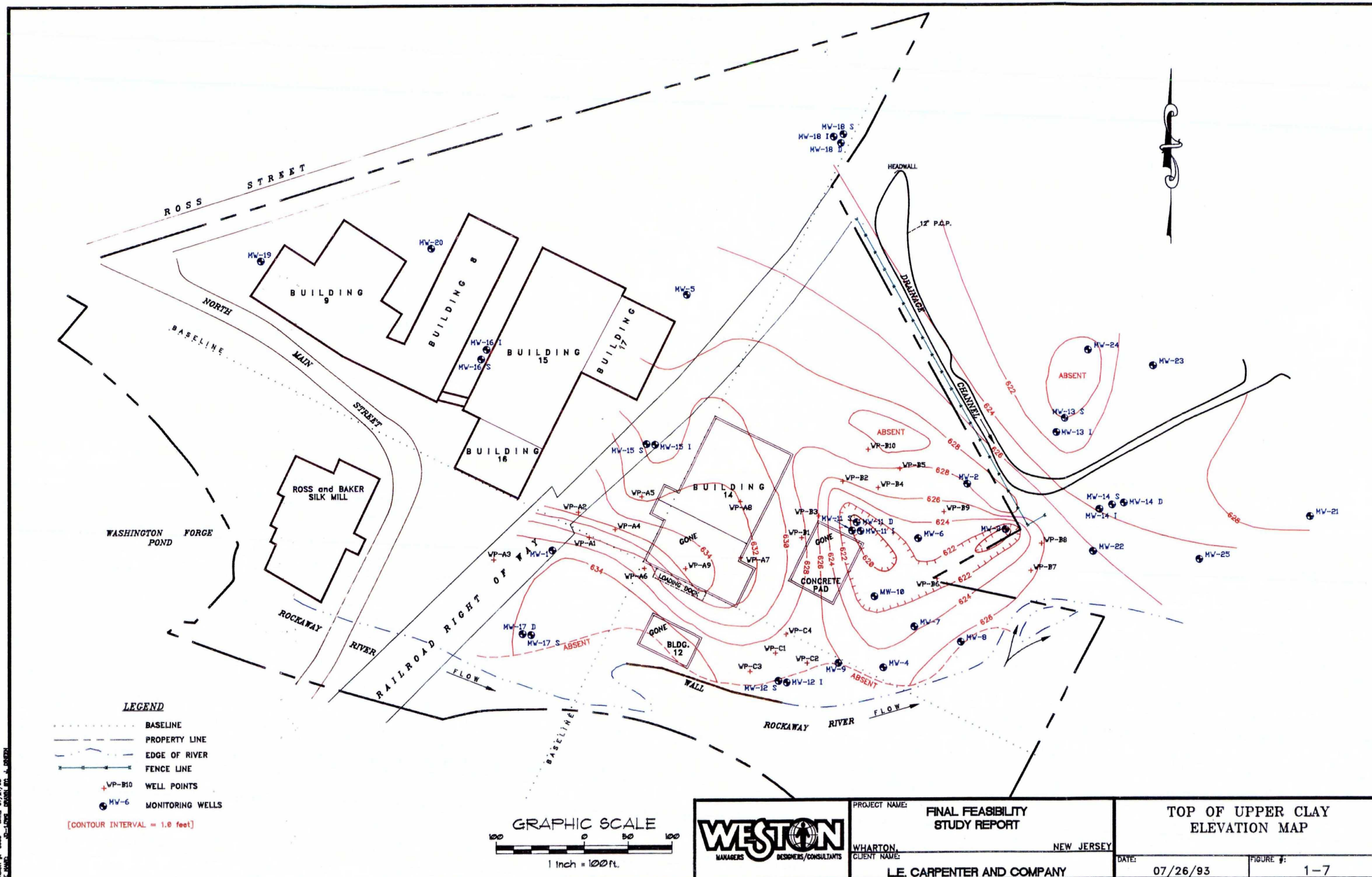
WHARTON, NEW JERSEY

CLIENT NAME: L.E. CARPENTER AND COMPANY

ISOPACH MAP OF PRODUCT THICKNESS

DATE: 07/26/93

FIGURE #: 1-6



WESTON
MANAGERS DESIGNERS/CONSULTANTS

PROJECT NAME: FINAL FEASIBILITY STUDY REPORT

WHARTON, NEW JERSEY

CLIENT NAME: L.E. CARPENTER AND COMPANY

TOP OF UPPER CLAY ELEVATION MAP

DATE: 07/26/93

FIGURE #: 1-7

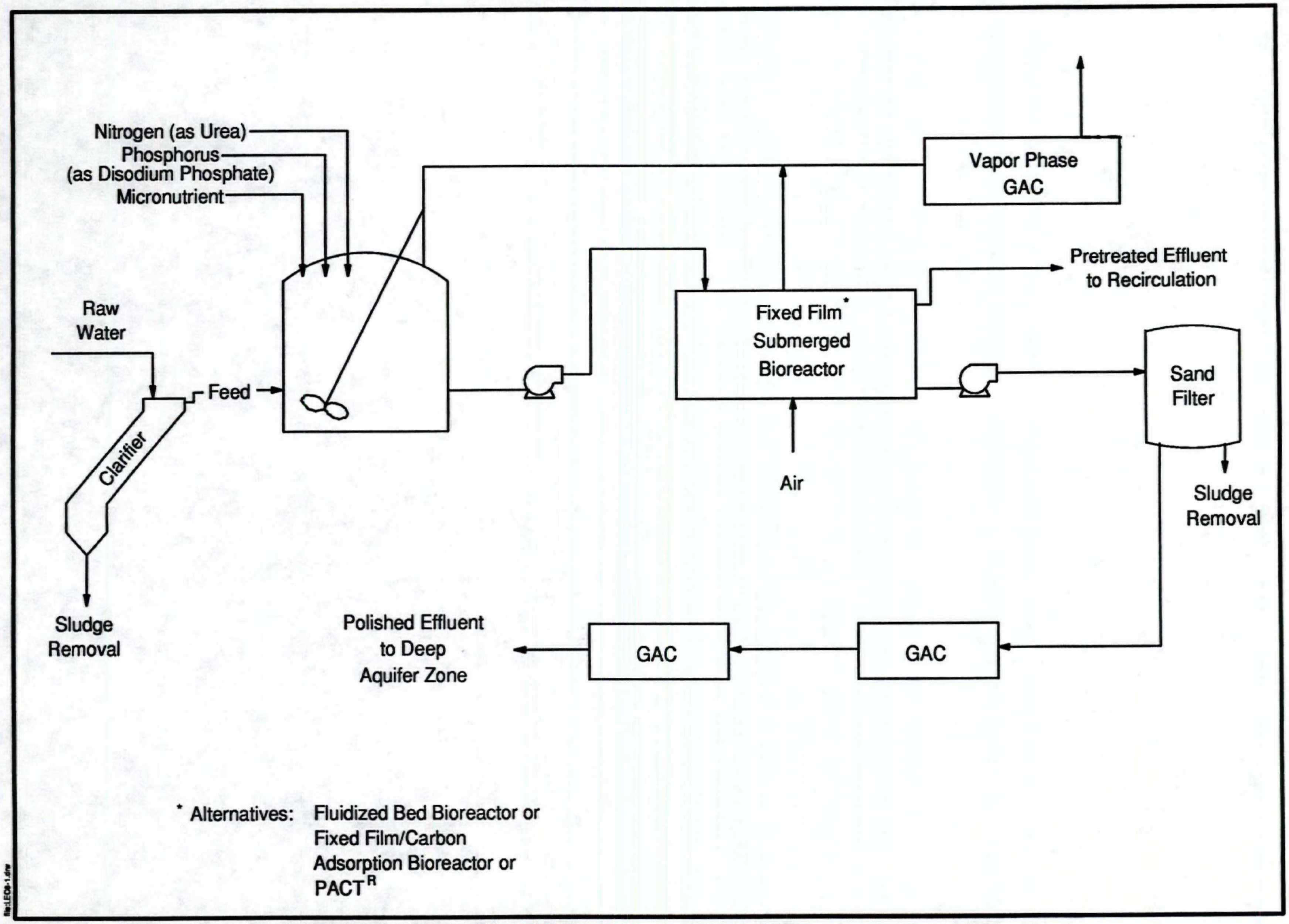
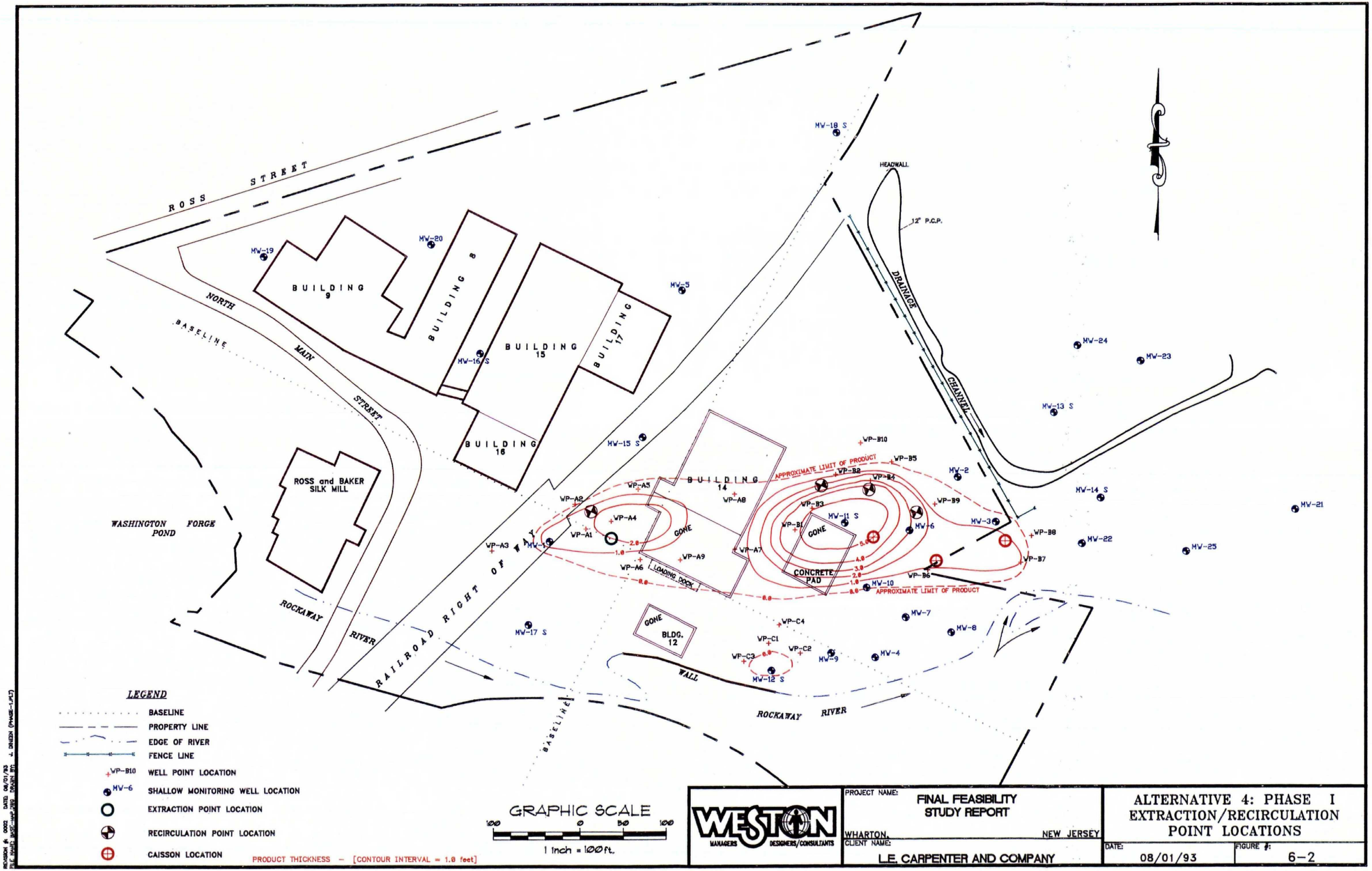


FIGURE 6-1 TYPICAL BIOLOGICAL TREATMENT SYSTEM SCHEMATIC



WESTON
MANAGERS DESIGNERS/CONSULTANTS

PROJECT NAME: FINAL FEASIBILITY STUDY REPORT

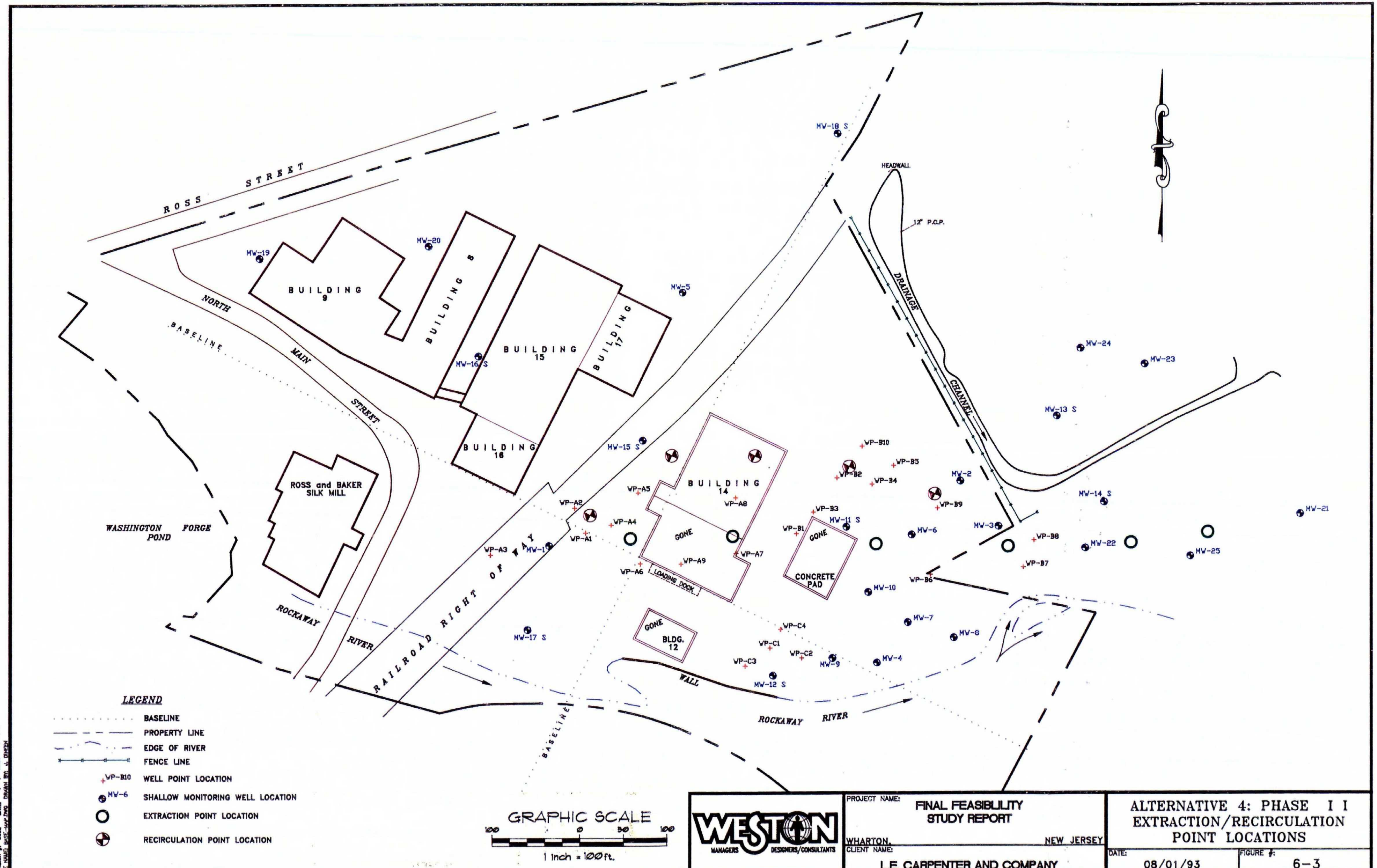
WHARTON, NEW JERSEY

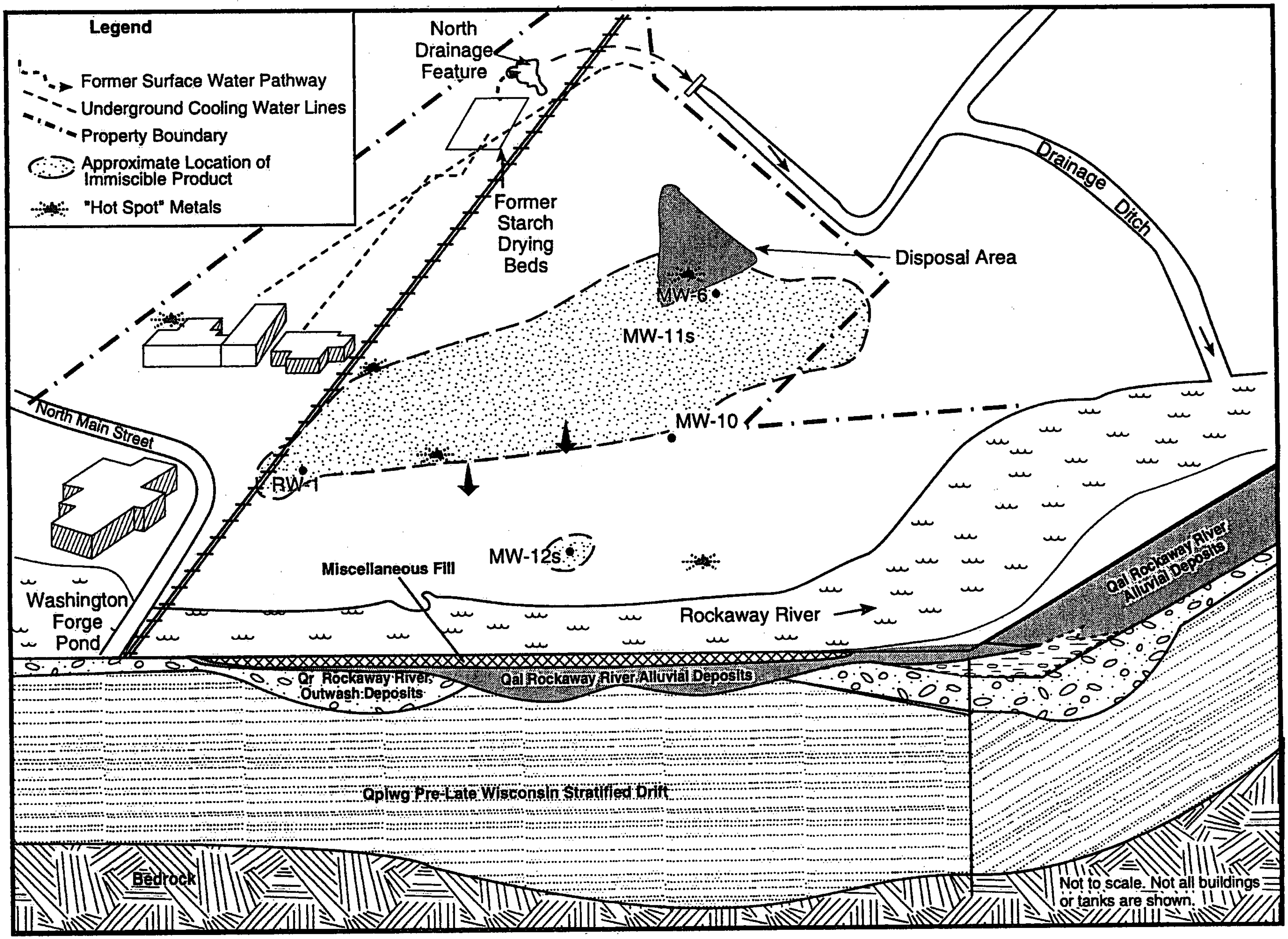
CLIENT NAME: L.E. CARPENTER AND COMPANY

ALTERNATIVE 4: PHASE I EXTRACTION/RECIRCULATION POINT LOCATIONS

DATE: 08/01/93

FIGURE #: 6-2

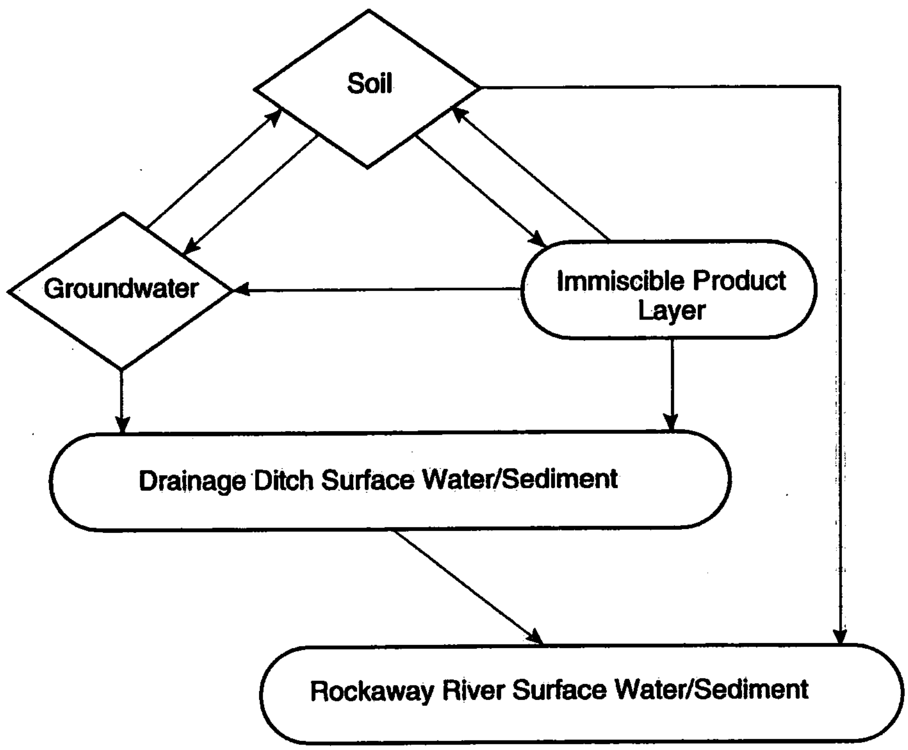

ROSS STREET
NORTH MAIN STREET
BASELINE
BUILDING 9
BUILDING 8
BUILDING 15
BUILDING 17
BUILDING 16
BUILDING 14
BLDG. 12
GONE
LOADING DOCK
CONCRETE PAD
ROSS and BAKER SILK MILL
WASHINGTON FORGE POND
ROCKAWAY RIVER
RAILROAD RIGHT OF WAY
WALL
HEADWALL
12" P.C.P.
DRAINAGE CHANNEL
MW-18 S
MW-19
MW-20
MW-5
MW-16 S
MW-15 S
MW-1
MW-17 S
MW-12 S
MW-9
MW-4
MW-7
MW-8
MW-10
MW-11 S
MW-6
MW-2
MW-3
MW-13 S
MW-14 S
MW-24
MW-23
MW-22
MW-25
MW-21
WP-A1
WP-A2
WP-A3
WP-A4
WP-A5
WP-A6
WP-A7
WP-A8
WP-A9
WP-B1
WP-B2
WP-B3
WP-B4
WP-B5
WP-B6
WP-B7
WP-B8
WP-B9
WP-B10
WP-C1
WP-C2
WP-C3
WP-C4
LEGEND
BASELINE
PROPERTY LINE
EDGE OF RIVER
FENCE LINE
WP-B10 WELL POINT LOCATION
MW-6 SHALLOW MONITORING WELL LOCATION
EXTRACTION POINT LOCATION
RECIRCULATION POINT LOCATION
GRAPHIC SCALE
100 0 50 100
1 inch = 100 ft.
WESTON
MANAGERS DESIGNERS/CONSULTANTS
PROJECT NAME:
FINAL FEASIBILITY STUDY REPORT
WHARTON, NEW JERSEY
CLIENT NAME:
L.E. CARPENTER AND COMPANY
ALTERNATIVE 4: PHASE II
EXTRACTION/RECIRCULATION POINT LOCATIONS
DATE: 08/01/93
FIGURE #: 6-3



708-7078A 7/23/93

FIGURE 1-8 L.E. CARPENTER CONCEPTUAL SITE MODEL

WESTON
MANAGERS DESIGNERS/CONSULTANTS

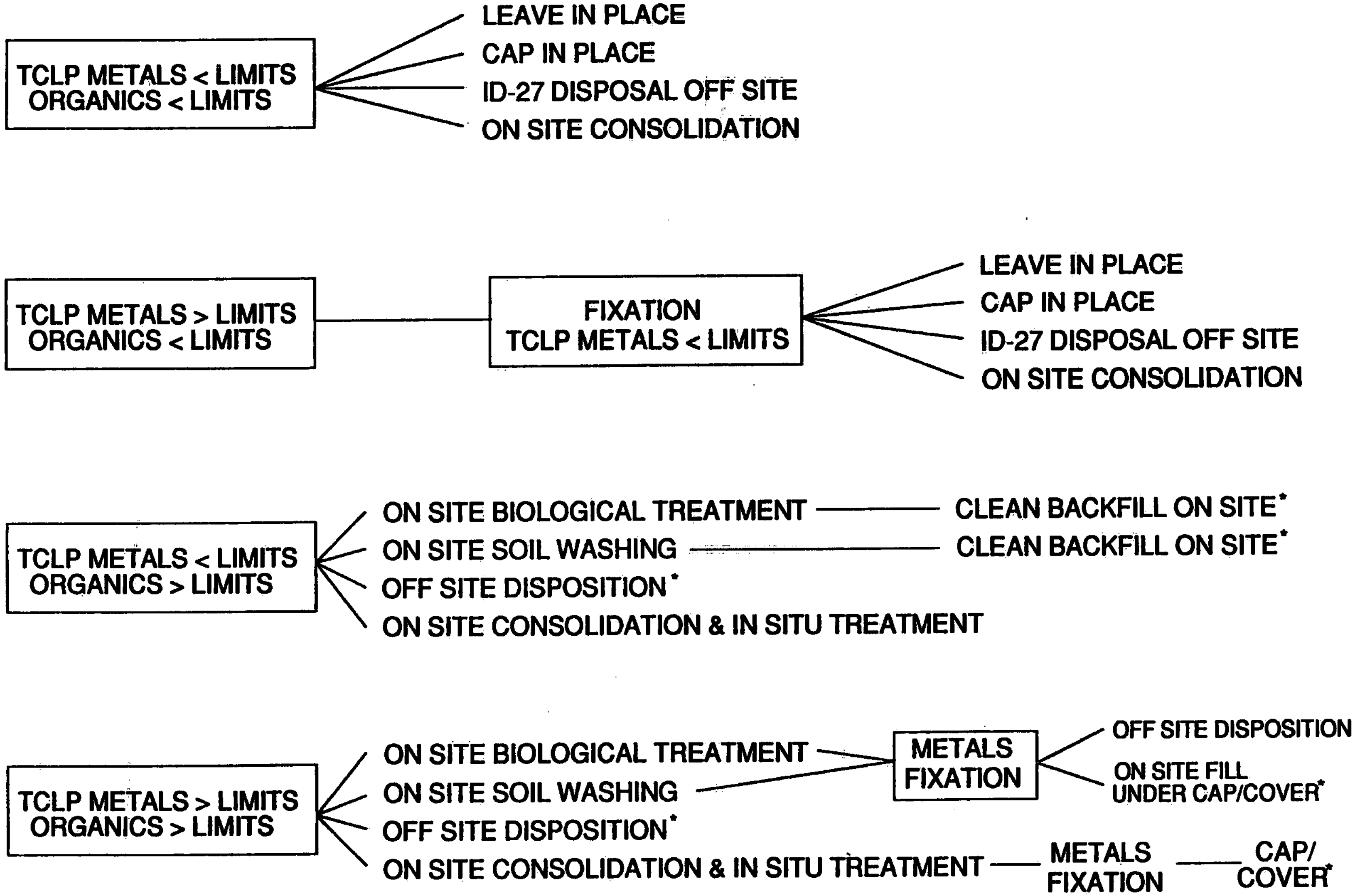


381 1644

FIGURE 1-9 CONCEPTUAL MODEL OF CONTAMINANT TRANSPORT

FIGURE 5-1

OPTIONS FOR DISPOSITION OF ISOLATED HOT SPOT SOILS



* SUBJECT TO LDRs

NOTE: PCB HOT SPOTS WILL BE EXCAVATED FOR OFF SITE DISPOSITION

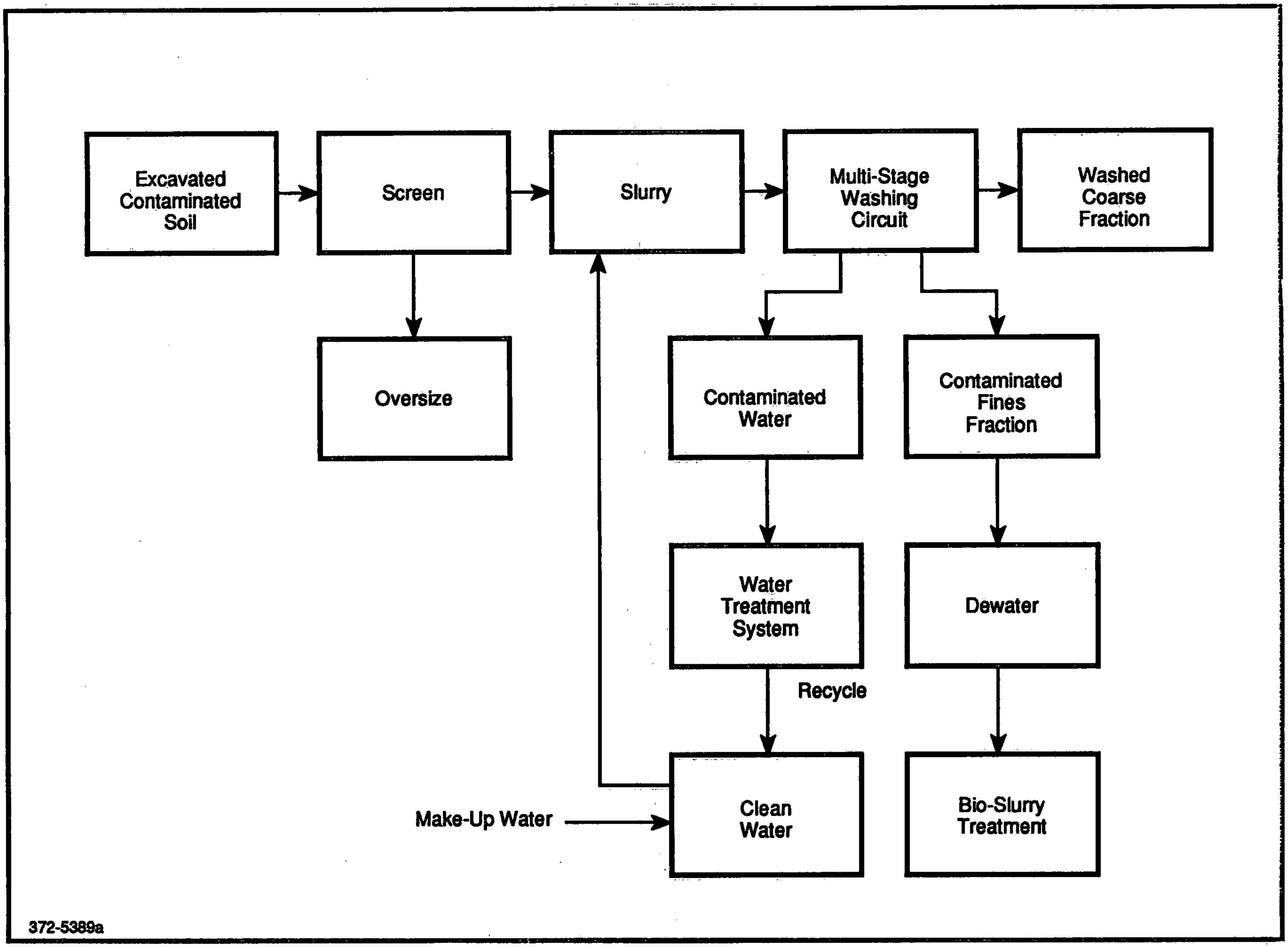
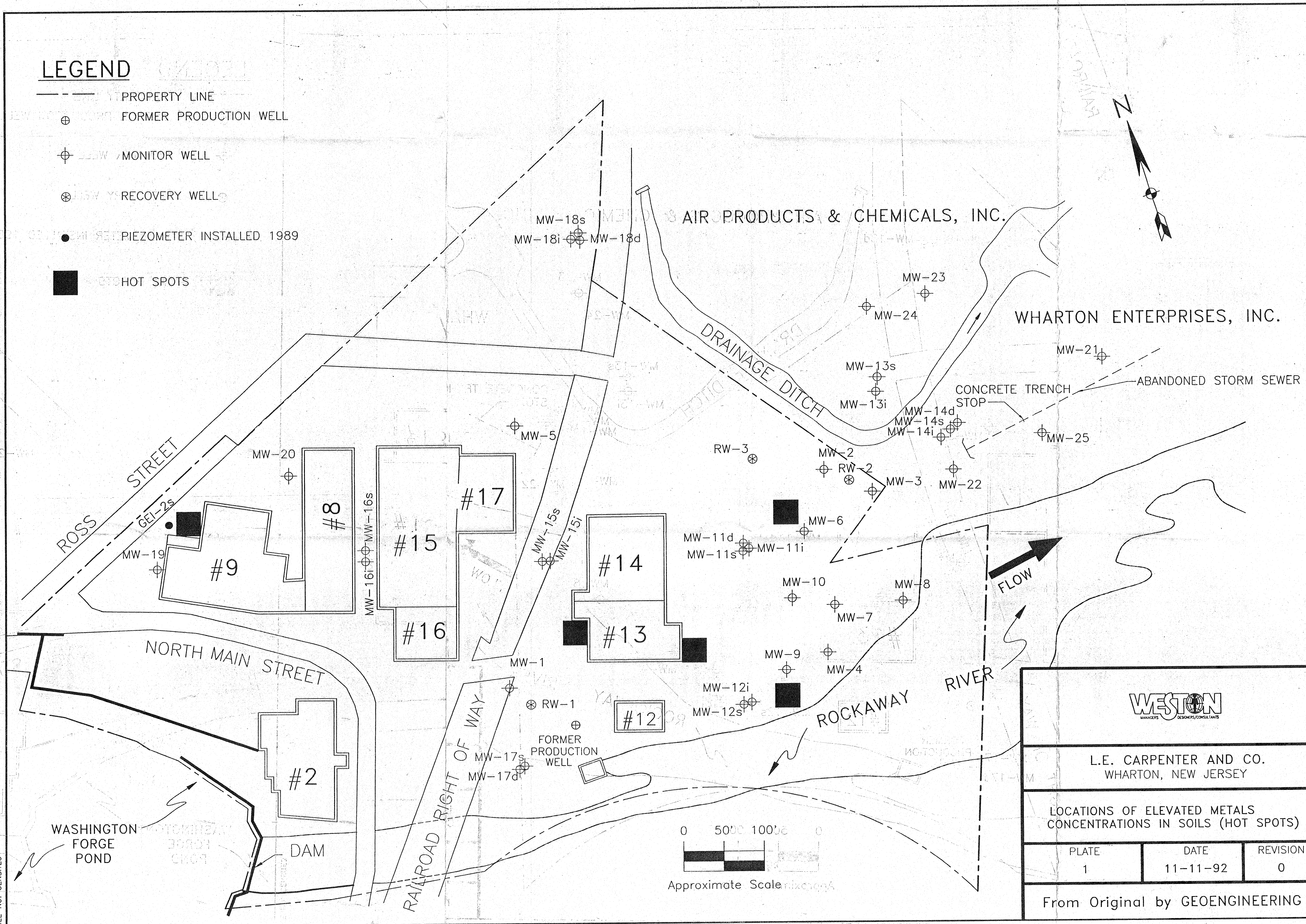


FIGURE 6-4 TYPICAL SOIL WASHING SYSTEM SCHEMATIC


LEGEND
PROPERTY LINE
FORMER PRODUCTION WELL
MONITOR WELL
RECOVERY WELL
PIEZOMETER INSTALLED 1989
HOT SPOTS
AIR PRODUCTS & CHEMICALS, INC.
WHARTON ENTERPRISES, INC.
N
DRAINAGE DITCH
CONCRETE TRENCH STOP
ABANDONED STORM SEWER
ROSS STREET
NORTH MAIN STREET
RAILROAD RIGHT OF WAY
ROCKAWAY RIVER
FLOW
WASHINGTON FORGE POND
DAM
FORMER PRODUCTION WELL
GEI-2s
MW-1
MW-2
MW-3
MW-4
MW-5
MW-6
MW-7
MW-8
MW-9
MW-10
MW-11d
MW-11s
MW-11i
MW-12i
MW-12s
MW-13s
MW-13i
MW-14d
MW-14s
MW-14i
MW-15s
MW-15i
MW-16s
MW-16i
MW-17s
MW-17d
MW-18s
MW-18i
MW-18d
MW-19
MW-20
MW-21
MW-22
MW-23
MW-24
MW-25
RW-1
RW-2
RW-3
#2
#8
#9
#12
#13
#14
#15
#16
#17
0
50'
100'
Approximate Scale
WESTON
MANAGERS DESIGNERS/CONSULTANTS
L.E. CARPENTER AND CO.
WHARTON, NEW JERSEY
LOCATIONS OF ELEVATED METALS CONCENTRATIONS IN SOILS (HOT SPOTS)
PLATE
1
DATE
11-11-92
REVISION
0
From Original by GEOENGINEERING
FILE NO. GENSITE3